In the United States Court of Federal Claims

No. 99-4451 L
c/w 99-4453L, 99-4454L, 99-4455L, 99-4456L, 99-4457L, 99-4458L, 99-4459L, 99-44510L, 99-44511L, 99-44512L, 00-365L, 00-379L, 00-380L, 00-381L, 00-382L, 00-383L, 00-384L, 00-385L, 00-386L, 00-387L, 00-388L, 00-389L, 00-390L, 00-391L, 00-392L, 00-393L, 00-394L, 00-395L, 00-396L, 00-398L, 00-399L, 00-400L, 00-401L, 05-1353L, 05-1381L, 06-72L

(E-Filed: September 28, 2007)

JOHN H. BANKS, ET AL., Plaintiffs, v. THE UNITED STATES, Defendant.	99-4451 L	Taking; Trial of Liability for Erosion of Beachfront Properties South of Harbor Jetties at St. Joseph, Michigan
EUGENE J. FRETT, Individually and as Trustee of the Victor J. Horvath and Frances B. Horvath Trust, Plaintiff, v. THE UNITED STATES, Defendant.	05-1353 L	

John B. Ehret, Olympia Fields, IL, for plaintiffs in Nos. 99-4451 L, 05-1381 L, and 06-72 L. Eugene J. Frett, Chicago, IL, pro se in No. 03-1353 L.

Terry M. Petrie, Denver, CO, with whom were Heide L. Herrmann and G. Evan Pritchard, Environment & Natural Resources Division, United States Department of Justice, Washington, DC, for defendant. Gary W. Segrest, Office of Counsel, United States Army Corps of Engineers, Detroit, MI, of counsel.

OPINION[1]

I. Procedural Background

The St. Joseph River enters Lake Michigan between St. Joseph, Michigan, and Benton Harbor, Michigan. Motion to Partially Dismiss and Memorandum in Support Thereof (Motion or Def.'s Mot.), Feb. 26, 2007, 5.[2] In the 1830s, the United States Army Corps of Engineers (Corps) re-constructed the mouth of the St. Joseph River and began constructing harbor jetties[3] that jutted generally westward into Lake Michigan in order to accommodate commercial shipping traversing the St. Joseph River into Lake Michigan. Id. The Corps lengthened the jetties periodically until they reached their present-day length in the year 1903. Id. From the early 1950s to 1989, the Corps incrementally encased the jetties in steel. Id.

In the 1970s, the Corps instituted a beach nourishment program to mitigate erosion along the shoreline south of the harbor jetties. Banks v. United States (Banks (accrual) II), 314 F.3d 1304, 1306-07 (Fed. Cir. 2003). "The Corps has provided fine sand nourishment for more than [fifteen] years on feeder beaches, deposited coarser sediments along the shoreline at least five times between 1986 and 1993, and placed barge-loads of large rocks into Lake Michigan in 1995." Def.'s Mot. 5-6. The Corps issued three technical reports in 1996, 1997, and 1999 (Reports), which "addressed the Corps'

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[1]The court attaches an Appendix at the end of this Opinion with a Table of Contents. Page numbers keyed to this slip opinion are shown in parentheses following each Table of Contents topic line.

[2]Facts relied on in this Opinion and cited to the filings of only one of the parties do not appear to be in dispute.

[3]This Opinion will refer to the harbor jetties at St. Joseph, Michigan, interchangeably as St. Joseph Harbor, the harbor, the piers, or the jetties.

mitigation efforts and collectively concluded that the erosion was permanent and irreversible." Def.'s Mot. 6; Banks (accrual) II, 314 F.3d at 1307.

Plaintiffs are the owners of property along approximately four and a half miles of the eastern shore of Lake Michigan south of St. Joseph Harbor. Def.'s Mot. 6; Banks (accrual) II, 314 F.3d at 1306. In July of 1999, sixteen of the current plaintiffs filed suit claiming that the Corps' construction and maintenance of the jetties from 1950 to 1989 caused erosion of their shoreline property. Def.'s Mot. 2, 6; see also Original Complaint of July 9, 1999, 2 ("Plaintiffs are riparian landowners who are uniformly suffering loss of property without just compensation arising out of the Defendant's construction and maintenance of fifteen jetties along the east coast of Lake Michigan."). By February 2000, the number of plaintiffs had increased to thirty-seven. Def.'s Mot. 2; Banks v. United States (Banks (accrual) I), 49 Fed. Cl. 806, 808 (2001).[4]

The United States moved to dismiss in February 2001, claiming that plaintiffs' actions were time-barred under 28 U.S.C. § 2501, which states that claims of which the Court of Federal Claims has jurisdiction must be filed within six years of accrual. Def.'s Mot. 2. The court granted the motion and dismissed plaintiffs' claims in July 2001. Banks (accrual) I, 49 Fed. Cl. at 826. The court reasoned that plaintiffs' takings claims were barred by the six-year statute of limitations no later than 1989 because the "gradual process of shoreline erosion set into motion by the government had resulted in a permanent taking and the extent of the damage had become reasonably foreseeable." Id. at 825.

The United States Court of Appeals for the Federal Circuit (Federal Circuit) reversed and remanded. Banks (accrual) II, 314 F.3d at 1305-06. Because a claim cannot accrue while the damages remain justifiably uncertain, the Federal Circuit stated that "the question is whether the 'predictability [and permanence] of the extent of damage to the [plaintiffs'] land' was made justifiably uncertain by the Corps' mitigation efforts." Id. at 1309 (citing Applegate v. United States (Applegate I), 25 F.3d 1579, 1583 (Fed. Cir. 1994)). The Federal Circuit held that "[w]ith the mitigation efforts underway, the accrual of plaintiffs' claims remained uncertain until the Corps' 1996 Report, 1997 Report, and 1999 Report collectively indicated that erosion was permanent and irreversible." Id. at 1310. These Reports "brought to an end plaintiffs' 'justifiable uncertainty' which had been created by the Corps's mitigation efforts about the permanency of erosion." Def.'s Mot. 4 (quoting Banks (accrual) II, 314 F.3d at 1310). The statute of limitations began to

[4]The Stone plaintiffs filed a Joint Stipulation of Dismissal with Prejudice on June 1, 2007; judgment was entered against the Stone plaintiffs as provided in Rule 54(b) of the Rules of the Court of Federal Claims (RCFC) on June 13, 2007, in case number 04-277 L.

run only after these Reports had been issued, and "[b]ecause the [R]eports were issued less than six years before plaintiffs filed their complaints, the Federal Circuit viewed each complaint as timely." Def.'s Mot. 4.[5]

After remand, the court consolidated the claims of all plaintiffs for the limited purpose of a trial of liability. See Order of Jan. 4, 2007; Order of Mar. 15, 2005; Order of Mar. 17, 2006 (consolidating Frett v. United States, No. 05-1353 (Fed. Cl. filed Dec. 22, 2005) into Banks et al. v. United States).

Defendant filed its Motion on February 26, 2007, Def.'s Mot. 1, arguing that the Federal Circuit's decision did not apply to fifteen of the plaintiffs (Banks (accrual) II plaintiffs) because these plaintiffs "had no justifiable uncertainty regarding the erosion to their property," Def.'s Mot. 12. In the time since the Banks (accrual) II decision, defendant alleged, new evidence had come to light: (1) "Some plaintiffs had no knowledge whatsoever of the Corps' efforts" to mitigate the loss, id., that is, they had no reason to believe that the clearly visible "permanent taking," Banks (accrual) I, 49 Fed. Cl. at 825, was not permanent, see Banks (accrual) II, 314 F.3d at 1310; and (2) "Others, while aware of the Corps' efforts, did not believe it would benefit their property," Def.'s Mot. 12, that is, they were not uncertain at all as to the permanency of the damage. Defendant further alleged that plaintiffs Bodnar and Okonski, who filed their complaints after the Banks (accrual) II decision, were barred by the statute of limitations because they were "on inquiry notice" of their claims and failed to file within the six-year limit. Id. at 19-22.

The court held, in its May 3, 2007, Opinion, that the accrual of a takings claim pursuant to 28 U.S.C. § 2501 was governed by an objective standard. Banks v. United States (Banks (accrual) III), 76 Fed. Cl. 686, 694-95 (2007). Therefore, plaintiffs' subjective knowledge and interpretations were irrelevant to the question of accrual, and the Federal Circuit's decision that these plaintiffs' claims did not accrue until the issuance of the Reports – and thus, are not barred by the six-year statute of limitations – still applied to the fifteen Banks (accrual) II plaintiffs. Id. at 696. The court further held that "[a]s landowners when the Reports were issued, the Okonski [and the Bodnar] plaintiffs are in the same position with respect to ownership of their property as the other plaintiffs who are subject to this Motion, that is, they purchased their property when the extent of the damage remained 'justifiably uncertain.'" Id. (citing Banks (accrual) II, 314 F.3d at 1309). The Bodnar plaintiffs were not barred by the statute of limitations because, having filed on December 28, 2005, they clearly fell within the six-year period of accrual that

[5]For additional background, see Banks v. United States (Banks (accrual) I), 49 Fed. Cl. 806, 807-08 (2001).

began with the issuance of the last of the Reports, the so-called "1999 Report," presumably in January of 2000. Id. The court deferred decision on the Okonski plaintiffs' claims because, without a more precise publication date for the 1999 Report, it was uncertain whether the January 27, 2006, filing date of their complaint was barred by the six-year statute of limitations. Id. at 696-97.

On May 15, 2007, the court issued its Opinion on the accrual of the Okonski plaintiffs' claims. Banks v. United States (Banks (accrual) IV), 76 Fed. Cl. 698 (2007). The court held that the objective standard governing accrual mandated "that accrual of plaintiffs' claims turns on some public availability or dissemination of the Reports." Id. at 701. Despite what appears to be an internal publication date of January 2000 of the last of these Reports, the evidence indicates that there was no public dissemination of this Report prior to January 27, 2000, and thus no constructive notice to plaintiffs of the information in that Report prior to that date. Id. Thus, the Okonski plaintiffs' January 27, 2006, claim was not barred by the statute of limitations. Id. at 701-02.

While pretrial discovery was underway, the court requested that the parties brief the issues of 1) over what period of time a plaintiff's claim is to be examined, and 2) on what date the high water mark is measured. Banks v. United States (Banks (scope) I), 68 Fed. Cl. 524 (2005). The court held that case law, as plaintiffs acknowledge, mandates that plaintiffs alleging a taking "may not bring a claim for any land lost prior to the time they purchased their respective properties." Id. at 528 n.7 (citing Banks' Plaintiffs' Memorandum in Support of Their Cross[-]Motion for Summary Judgment as to the Period of Claim Examination and the High Water Mark, Mar. 30, 2005, Docket No. 68 in Case No. 99-4451 L (Banks Opp'n), 6); Banks Plaintiffs' Reply Memorandum in Support of [Their] Cross[-]Motion for Partial Summary Judgment as to the Period of Claim Examination (POCE) and High Water Mark (HWM), May, 19, 2005, Docket No. 80 in Case No. 99-4451 L, 7 ("All claims are valid and the period of examination is from the date of purchase until the plaintiffs are paid."). Further, the court held that the federal navigational servitude is a pre-existing encumbrance on a landowner's title, Banks (scope) I, 68 Fed. Cl. at 531, thereby precluding compensation for encroachments existing at the time of purchase pursuant to this servitude, see id. Nevertheless, landowners may be compensated for damage to their properties beyond the scope of the servitude, namely, "land located above or outside . . . the high water mark at the time of construction." Id. at 534 (quoting Owen v. United States, 851 F.2d 1404, 1412 (Fed. Cir. 1988)) (omission and emphasis in original). Although the piers were initially constructed in 1836, plaintiffs argued, and the court agreed, that "[t]he 'time of construction' . . . is the thirty-nine year period, specifically between 1950 and 1989, during which the Corps installed steel sheet piling to the St. Joseph Harbor jetties." Id. at 527 (citing Banks Opp'n 3). "For the foregoing reasons, the court must examine each plaintiff's claim during the liability phase

of trial from the acquisition date of the plaintiff's property through the date of claim accrual in January 2000"[6] but no earlier than 1950, the year when the Corps began its steel construction and from which time the high water mark will be measured. Id. at 535 (emphasis added).[7] Plaintiffs subsequently moved for clarification of the term "high water mark," which the court denied, stating that:

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[6]The law of the case doctrine has established that "[w]hen a case has been once decided by [a superior court,] . . . . [t]he [lower court] is bound by the decree as the law of the case." In re Sanford Fork & Tool Co., 160 U.S. 247, 255 (1895). This doctrine does not apply, in relevant part, when there is "discovery of new and different material evidence that was not presented in the prior action." Intergraph Corp. v. Intel Corp. (Intergraph), 253 F.3d 695, 698 (Fed. Cir. 2001). When a prior decision by the same court "is clearly incorrect and its preservation would work a manifest injustice," id., the same court may depart from the law of the case, see e.g., Gould, Inc. v. United States, 67 F.3d 925, 927-28 (Fed. Cir. 1995); DeLong Equip. Co. v. Washington Mills Electro Minerals Corp., 990 F.2d 1186, 1197 (11th Cir. 1993); Terrell v. Household Goods Carriers' Bureau, 494 F.2d 16, 19-20 (5th Cir. 1974). For a more detailed analysis of the law of the case doctrine, see Banks v. United States (Banks (accrual) III), 76 Fed. Cl. 686, 689-91 (2007). The law of the case doctrine affects, in two respects, the phrase "through the date of claim accrual" in the court's opinion in Banks v. United States (Banks (scope) I), 68 Fed. Cl. 524, 535 (2005).

First, an opinion of the court subsequent to Banks (scope) I held that despite what appears to be an internal publication date of January 2000 of the last of the 1996, 1997, and 1999 Reports, the evidence indicates that there was no public dissemination of this Report prior to January 27, 2000, and thus no constructive notice to plaintiffs of the information in that Report prior to that date. Banks v. United States (Banks (accrual) IV), 76 Fed. Cl. 698, 701 (2007). The implication of Banks (accrual) IV is that the date of accrual is, in any case, no earlier than January 27, 2000. Second, even if the date of accrual is not definitively fixed, the court is charged with determining the extent of any damage that is "permanent and irreversible," Banks (accrual II), 314 F.3d 1304, 1310 (2003), which necessarily contemplates damage that occurs after the date of claim accrual, Banks (scope) I, 68 Fed. Cl. at 530 n.12 ("As a matter of law, each plaintiff is entitled to '"just compensation" [that] includes . . . recovery for "all damages, past, present and prospective."'" (quoting Ridge Line, Inc. v. United States, 346 F.3d 1346, 1359 (Fed. Cir. 2003))).

[7]These parameters are a prior holding of the court binding the parties. Notwithstanding that the law of the case established that damages would be tried for a period "no earlier than 1950" above the ordinary high water mark, Banks (scope) I), 68 Fed. Cl. at 535, plaintiffs claim damages for "all the beach lost below the [ordinary high water mark]," Plaintiffs' Opening Post Trial Brief (Plaintiffs' Brief or Pls.' Br.), July 6, 2007, 47, and have changed their litigation position in trial briefing to claim damages caused since the construction of the jetties in 1836 and prior to the acquisition by many plaintiffs of their properties, see Part V.A.1.

> Federal case law alternates between the use of the terms "high water mark" and "ordinary high water mark" to describe the boundary of the navigational servitude . . . . Accordingly, the court here declines to clarify the terminology as requested by plaintiffs [and further to define the scope of the Corps' navigational servitude]. The court will, at trial, determine the specific location of the appropriate boundary with reference to the regulations and case law.

Banks v. United States (Banks (scope) II), 71 Fed. Cl. 501, 506 (2006).[8] The court also denied plaintiffs' motion to certify certain questions propounded by plaintiffs, which concerned questions of federal law, to the Michigan Supreme Court. Id. at 509.

On June 23, 2005, the court directed the parties to brief the issue of "whether the Corps [may be] liable for any erosion caused by plaintiffs' own efforts to mitigate the damage from the Corps' activities in St. Joseph Harbor by placing shore protection on their respective properties." Banks v. United States (Banks (revetments) I), 69 Fed. Cl. 206, 208 (2006) (quoting Order of June 23, 2005). Extensive briefing followed from both parties, which included the Banks plaintiffs' Answer as to Whether the Corps is Liable for Any Erosion Caused by Plaintiffs' Own Efforts to Mitigate the Damage from the Corps' Activities in St. Joseph Harbor by Placing Shore Protection on Their Respective Properties, defendant's Motion for Partial Summary Judgment as to the Erosion Caused by Plaintiffs' Shore Protection, and the Banks plaintiffs' Motion to Take Judicial Notice of the Michigan Supreme Court ruling on July 29, 2005 in Glass v. Goeckel[,] Docket no. 126409. Banks (revetments) I, 69 Fed. Cl. 208-09.[9] The court noted in its opinion that plaintiffs asserted that, of the thirty-seven plaintiffs in the consolidated case at the time, only plaintiff Del Mariani had not installed shore protection. Id. at 210. The court held, in relevant part, that property damage that results from the presence of protective structures is a "direct, natural, or probable result" of defendant's actions – as evidenced by the consideration of potential damage to the property of others during the permitting process – and property damage resulting from shore protection installed by plaintiffs is a compensable injury if plaintiffs establish at trial a causal link between defendant's activities and the construction of the revetments, the limitation of liability language in the permit application form for authorization to construct the protective structures notwithstanding. Id. at 214, 217. Accordingly, the Corps will be liable for damage

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[8]The location of the high water mark was not addressed in the trial of liability. See Banks Trial Transcript (Tr.) passim. The subject will, however, necessarily arise in any trial of damages.

[9]For a complete description of the briefing, refer to Banks v. United States (Banks (revetments) I), 69 Fed. Cl. 206, 208-209 (2006).

caused by plaintiffs' revetments to plaintiffs' properties if defendant's activities can be shown to have caused damage to plaintiffs' properties compensable as a taking.

Trial on liability began on Monday, June 4, 2007, and concluded on Friday, June 8, 2007.[10] The court heard testimony from 22 witnesses[11] and received some 75 exhibits

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[10]The day before the trial, the court conducted a site visit with plaintiffs, defendant, and some witnesses. Order of Mar. 16, 2007; Joint Status Report Regarding Site Visit, Apr. 6, 2007; Order of Apr. 12, 2007. As the court made clear prior to the trial, this visit was off the record and did not constitute evidence. Order of Apr. 12, 2007, 2; Banks Pretrial Transcript (Pretrial Tr.) 162:4-10.

[11]For convenient reference, the name, in alphabetical order, and a description of each witness upon whose live testimony the court relies in this opinion follows:

Mr. Stephen P. Blumer, a supervisory hydrologist at the United States Geological Survey (USGS), Tr. 955:22-956:1, is a fact witness for plaintiffs, Plaintiffs' Filing of Trial Exhibits and Witnesses Pursuant to Court Order (Docket 206 - 5/10/07) (Pls.' Wit.), filed May 11, 2007, 20. In that position, he runs USGS data programs, oversees those programs in the state of Michigan, and reviews USGS surface water, groundwater, and water quality data collection programs. Tr. 956:1-4. Mr. Blumer earned a bachelor's degree in forest hydrology from Michigan Technological University and did graduate studies in a watershed hydrology program at the University of Arizona. Id. at 955:16-21.

Ms. Gail Lois Chapman, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.' Wit. 27. She and her husband own property along the St. Joseph River, which they bought in 1966. Tr. 274:11-14. Ms. Chapman has lived in St. Joseph since she was two years old. Id. at 274:19-20. She holds a bachelor of science degree in education from Central Michigan and a master's degree in library science from the University of Michigan. Id. at 274:23-275:1.

Dr. Michael John Chrzastowski, a Senior Coastal Geologist with the Illinois State Geological Survey, is an expert witness for plaintiffs. Tr. 166:1-2, 169:6-13. He has bachelor's degrees in oceanography, geology, and geography and a master's degree and Ph.D. in coastal geology. Id. at 166:16-20. He earned his bachelor's degrees at the University of Washington, his master's degree at Western Washington University, and his doctorate at the University of Delaware. Id. at 166:23-167:1. He focuses on coastal erosion, an area in which he has worked since 1974. Id. at 168:18-23. He joined the Illinois State Geological Survey in 1987. Id. at 169:1-2. The court qualified Dr. Chrzastowski as an expert in littoral drift, coastal geology, equilibrium beaches, grain size of sand and sediment, down-cutting, glacial till, lake bed lowering, and erosion and its causes. Id. at 169:6-13.

Ms. Carole L. Ehret, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.'

Wit. 28. She graduated from the University of Michigan in 1953 with a bachelor of arts degree in English literature. Tr. 737:11-12. She was raised in St. Joseph and lives there currently. See id. at 738:15-739:1.

Mr. James Mitchell Ellison III, Chief Boatswain Mate in the United States Coast Guard, Tr. at 315:18-316:2, is a fact witness for plaintiffs, Pls.' Wit. 21. He has been in that position since 1994. Tr. 315:23-24. He was stationed in St. Joseph from 1997 to 2000. Id. at 316:8-9.

Mr. Martin Richard Jannereth, Chief of the Lake, Streams, and Shoreland Section of the Land and Water Management Division of the Michigan Department of Environmental Quality (MDEQ), Tr. at 920:6-16, is a fact witness for plaintiffs, Pls.' Wit. 22. He has worked for MDEQ and its predecessor, the Department of Natural Resources, for over thirty-three years. Tr. 920:10-13. He holds a bachelor's degree in forestry and a master's degree in forest ecology with an emphasis on soil science from Michigan State University. Id. at 920:3-5.

Mr. Dean King, a resident of Holland, Michigan and employed in The King Company, a dredging and pile driving business, Tr. at 329:14-330:7, is a fact witness for plaintiffs, Pls.' Wit. 22. The King Company contracts with the United States Army Corps of Engineers (Corps), and it has done hundreds of jobs for that entity. Tr. 330:10; 330:23-24. The King Company has performed maintenance dredging in St. Joseph Harbor for the government. Id. at 331:1-5.

Mr. John Konik, employed as Chief of the Regulatory Office of the Corps, Detroit District, Tr. 1345:2-8, is a fact witness for defendant. He has worked for the Corps' regulatory division for twenty-seven years. Id. at 1345:4-16. In his current position, he manages the regulatory program for the Detroit District. Id. at 1345:19.

Dr. Grahame J. Larson is an expert witness for defendant who was also called as a fact witness for plaintiffs. See id. at 860:3-20; 972:16-976:17. He is a professor of hydrogeology, glacial geology, and introductory geology at Michigan State University. Tr. at 855:1-4. He holds bachelor's and master's degrees in geology from Ohio Wesleyan University and a Ph.D. in geology from Ohio State. Id. at 855:9-12. He has taught at Michigan State University for about thirty years. Id. at 855:13-15. The court qualified Dr. Larson as an expert in glacial geology, glaciology, and hydrology. Id. at 976:22-25.

Mr. Lloyd Richard Marzke, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.' Wit 28. He bought property along the St. Joseph River in 1969. Tr. 886:3-4.

Dr. Guy Allen Meadows, professor of Physical Oceanography in the Department of Naval Architecture and Marine Engineering and the Department of Atmospheric, Oceanic and Space Sciences at the University of Michigan, Tr. 28:12-16, is an expert witness for plaintiffs, id. at 32:12-33:22. He holds two degrees in mechanical engineering and a Ph.D. from Purdue University. Id. at 28:20-23. His major area of focus is "coastal hydrodynamics with an emphasis

on experimental measurements at full scale, meaning [he makes] measurements in the real world as opposed to laboratories." Id. at 28:25-29:3. He has taught at the University of Michigan since 1977, id. at 32:2, and he has studied Lake Michigan for most of his career, id. at 29:9-10. The court qualified Dr. Meadows as an expert in littoral drift, littoral zone, equilibrium beach, the granular structure of sand, the depth of closure, net littoral drift, gross littoral drift, and the navigational characteristics of the piers at the St. Joseph Harbor. Id. at 32:12-33:22.

Mr. Robert Dale Melcher, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.' Wit. 28. He lives in the Grand Mere area between North Grand Mere Lake and Lake Michigan, on property he bought in approximately 1971. Tr. 506:4-5;507:1-3.

Mr. Donald D. Miller, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.' Wit. 28. He was born and raised in St. Joseph. Tr. 780:15. He currently owns property in St. Joseph that originally belonged to his parents and on which he built a house in 1959. Id. at 780:22-25.

Dr. Robert B. Nairn, a coastal engineer employed by W.F. Baird & Associates (Baird), id. at 1080:3-21, is an expert witness for defendant, id. at 1107:22-24; see id. at 1081:8-1082:3. He has worked as a coastal engineer for approximately 25 years, id. at 1080:5-6, and he has worked at Baird since 1992, id. at 1080:22-23. Dr. Nairn received a bachelor of science degree in civil engineering from Queens University in Kingston, Ontario, in 1982. Id. at 1082:11-14. In 1985, he received a master's degree in coastal engineering at Queens University. Id. at 1082:21-23. He then earned a Ph.D. in coastal processes, coastal engineering, sediment transport from Imperial College, London. Id. at 1082:25-1083:2. The court qualified Dr. Nairn as an expert witness in coastal engineering, river engineering, coastal processes, sediment transport, including the use of a sediment budget and the calculation of longshore transport rate, numerical modeling, and shore protection, including shore protection design, impacts of coastal structures on shore erosion, and beach erosion. Id. at 1107:22-24; see id. at 1081:8-1082:3.

Mr. Thomas William O'Bryan, a fact witness for plaintiffs, Pls.' Wit. 24, is the Chief of the Construction Branch of the Corps, a job in which he oversees contract administration related to any construction or contract work of the Corps, Tr. 719:20-23. He graduated from Wayne State University in 1981 with a bachelor of science degree in civil engineering. Id. at 719:5-8. He has worked for the Corps since 1978. Id. at 719:11-12.

Dr. James Patrick Selegean is a fact witness for plaintiffs, Pls.' Wit. 7, and defendant's witness under RCFC 30(b)(6), Defendant's Motion for Leave to File Correct Response to Court Order Filed May 10, 2007 RE: Witnesses and Exhibits, Ex. 3, 4; RCFC 30(b)(6) (describing witnesses "designate[d by a governmental agency] who consent to testify on [the governmental agency's] behalf"). He is a hydraulic engineer for the Detroit District of the Corps. Tr. 325:20-326:3. He has been employed there for about fifteen years. Id. at 325:23-24. His work involves monitoring erosion processes on the Great Lakes, running wave models, and determining

sediment transport along shorelines and in rivers. Id. at 326:5-9. He holds a bachelor of science degree in civil engineering, a master's degree in civil and environmental engineering, a master's degree in biology, and a Ph.D. in environmental engineering. Id. at 326:12-17. He earned all of his degrees at Wayne State University. Id.

Mr. David L. Schweiger, the Chief of the Engineering Design and Construction Office of the Corps, id. at 705:21-22, is a fact witness for plaintiffs, Pls.' Wit. 25. In that position, he oversees the design of civil works projects within the jurisdiction of the Corps and all construction activities, civil and military works, within the Detroit District. Tr. 705:24-706:3. Previously, Mr. Schweiger was the Assistant Chief of the Engineering and Technical Services Division from December 2001 until January 2004 and the Chief of the Hydraulics and Hydrology Division from 1996 through 2001. Id. at 706:4-14. As Chief of the Hydraulics and Hydrology Division, Mr. Schweiger was responsible for the Corps' issuing of monitoring reports. Id. at 706:15-17. He earned a bachelor of science degree in civil engineering from Michigan State University in 1973. Id. at 705:5-6.

Mr. Scott J. Thieme, Chief of the Great Lakes Hydraulics and Hydrology office of the Detroit District of the Corps, id. at 490 6-8, is a fact witness for plaintiffs, Pls.' Wit. 26. He has a bachelor's degree in civil engineering, and he has spent most of his career at the Corps in civil engineering, mostly hydraulics and hydrology. Tr. 489:24-490:1.

Mr. Charles Lyle Thompson, employed by the Detroit District Corps from 1979 to 2003, id. at 397:17-19, is a fact witness for plaintiffs, Pls.' Wit. 26. During that time, he worked exclusively with the hydraulics and hydrology branch where he studied the flow measurements of rivers. Tr. 397:17-398:6. He performed work on the Lake Michigan coastline between St. Joseph and New Buffalo. Id. at 398:16-19. Mr. Thompson holds a bachelor's degree in earth science from the College of Minnesota, and he has done some graduate work in ocean engineering at the University of Michigan. Id. at 398:10-12. He also took classes at Lawrence Tech and Wayne State University. Id. at 398:12-13.

Mr. Richard Albert Voss, a fact witness for plaintiffs, Pls.' Wit. 26, was raised in St. Joseph and continues to live there now, Tr. 787:20-788:4. He retired over a year ago from his employment as a real estate appraiser. Id. at 787:15-19. He attended one semester of college and received "significant education in real estate industry in both brokerage and appraisal." Id. at 787:12-14.

Ms. Marcia Wineberg, one of the plaintiffs in this case, is a fact witness for plaintiffs. Pls.' Wit. 28. She currently works as an administrative assistant at the Portland Cement Association in Skokie, Illinois. Tr. 242:25-243:2. She graduated from high school and completed one year of college. Id. at 242:23-24. Ms. Wineberg and her husband own property along the St. Joseph River, which they bought in two stages. Id. at 243:11-13.

into evidence. Banks Trial Transcript (Tr.) passim.

After trial, the parties submitted the following briefing: Plaintiffs' Opening Post Trial Brief (Plaintiffs' Brief or Pls.' Br.), Defendant's Post-Trial Brief (Defendant's Brief or Def.'s Br.), Plaintiffs' Response to Defendant's Post Trial Brief (Plaintiffs' Response or Pls.' Resp.), and Defendant's Response to Plaintiffs' Post-Trial Brief (Defendant's Response or Def.'s Resp.). The court notes that plaintiffs organize their briefing in a series of paragraphs that refer to evidence in a delphic manner: Plaintiffs often fail to explain their interpretations of that evidence and the relevance of that evidence to their argument. See e.g., Pls.' Br. 22 ("PX94-19, PX Summary Tab 7.3 shows 110,000 cy/y southbound at St. Joseph 1322:3-22."). This approach results in arguments that are at best difficult to follow and, at worst, in defendant's characterization, "indecipherable." Def.'s Resp. 1; see generally Pls.' Br. passim; Pls.' Resp. passim. The court's difficulty in interpreting plaintiffs' briefing and, therefore, plaintiffs' view of the correct interpretation of the evidence at trial, is exacerbated by plaintiffs' making irrelevant arguments (given the scope of the trial and prior decisions on this case by the court) and assuming inconsistent positions. See Def.'s Resp. 1. The court made its best efforts, with help from Plaintiffs' Memorandum of Law and Facts (Plaintiffs' Memorandum or Pls.' Mem.) as further guidance, to interpret plaintiffs' theories of the case based on plaintiffs' briefing and the available evidence.

II. Background: Littoral Processes, Removal of Material from the Littoral System, Erosion, Mitigation, and Major Issues

"Sediment[12] transport very simply is the movement of sand, clay or silt driven by

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Mr. Jay Kevin Wesley, a fisheries manager for the Department of Natural Resources of the State of Michigan, id. at 897:17-20, is a fact witness for plaintiffs, Pls.' Wit. 27. In that position, he manages all of the southwest Michigan inland lakes and streams and the southern part of Lake Michigan. Tr. 897:22-23. He has a bachelor's degree in fisheries biology from Michigan State University and a master's degree in natural resource management from the University of Michigan. Id. at 898:2-4.

[12]The witnesses at trial used the term "sediment" in differing ways. See, e.g., Tr. 34:15-17 (Meadows) ("By sediment I'm referring to sand size particles . . . ."); Tr. 176:21-23 (Chrzastowski) ("And the sediment that's deposited at the bottom of glacial ice is till, and it's a very compact silt and clay and may contain pebbles."). The court understands the word "sediment" in common usage to be a generic term as defined in the second definition in the American Heritage Dictionary, relevant to this litigation: "Solid fragments of inorganic or organic material that comes from the weathering of rock and are carried and deposited by wind, water, or ice." American Heritage Dictionary 1575 (4th ed. 2000); Tr. 1102:25 (Nairn)

the motion of water." Tr. 1099:8-9 (Nairn). This term could be used interchangeably with "littoral drift." Tr. 1039:3 (Larson) ("Littoral drift is transport."); Pls.' Br. 26; see, e.g., Tr. 39:16-40:8 (Meadows). Sediment transport occurs along the nearshore profile, which is "from the shoreline lakeward to the extent of wave influence on changes on the bottom." Tr. 190:6-10 (Chrzastowski). The littoral zone or littoral system is the area along the shoreline where sediment transport occurs. See, e.g., Tr. 34:12-20 (Meadows); Tr. 1161:8-10, 1330:8-11 (Nairn). The depth of closure is a point from the shore beyond which "there is never enough energy to move [sediment particles] again," Tr. 40:22-25 (Meadows), that is, a point beyond the littoral zone. Experts have opined that the depth of closure is at different locations: Dr. Guy Allen Meadows estimated it to be between 18 and 21 feet of depth for most of the Lake Michigan coast, Tr. 41:1-2, 43:3-14 (Meadows); Dr. James Patrick Selegean testified that he believes the depth of closure to be "closer to the 30-foot range, although [he has not] done any calculations to support that," Tr. 610:15-20 (Selegean); and Dr. Robert B. Nairn testified that it was at a "depth greater than 10 or 15 or 20 meters [10.9 or 16.35 or 21.8 yards][13]," Tr. 1214:23-24 (Nairn). The zone beyond the depth of closure is known as "deep water." See Tr. 610:11-13 (Selegean).

A sediment source is what provides sediment into the littoral zone for transport. See, e.g., Tr. 34:18-20 (Meadows). A sediment sink, on the other hand, is a place that traps sediment, removing it from sediment transport and thus from the littoral system. See Tr. 191:1-7 (Chrzastowski). Sinks are usually depressions on the lake bed deep enough that wave action can no longer influence sediment movement, which results in the sediment trap. Id.

It is undisputed in this case that the long-term net littoral drift in the area of St. Joseph Harbor moves from north to south. Plaintiffs' Exhibit (PX) 93 (Section 111 Detailed Project Report on Shore Damage at St. Joseph Harbor, Michigan (1973 Report)) 11; PX 22 (Mitigation of Shore Damage Attributed to the Federal Navigation Structures at St. Joseph Harbor, Michigan (1974 Report)) 231; PX 24 (Effectiveness of Beach Nourishment on Cohesive Shores, St. Joseph, Lake Michigan (1997 Report)) 3; PX 23 (Geologic Effects on Behavior of Beach Fill and Shoreline Stability for Southeast Lake Michigan (1996 Report)) 9; Tr. 1277:4-13 (Nairn); Pls.' Br. 20; PX 33 (Preliminary Results of a Pilot Study Conducted Between St. Joseph, Michigan and Michigan City,

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("sediment . . . is lifted and moved"). Further technical specificity is supplied by the context in which the word is used, especially by testifying experts.

[13]The conversion from meters to yards was calculated by multiplying each metric measurement by 1.09. American Heritage Dictionary 1088 (4th ed. 2000).

Indiana (1992 Pilot Study)) 10; Tr. 39:2-15 (Meadows); Tr. 172:6-9, 173:8 (Chrzastowski); see Def.'s Br. passim. It is also undisputed that the disruption of littoral drift by St. Joseph Harbor depletes sediment supply in the littoral zone and causes erosion. PX 93 (1973 Report) 29; PX 101 (REVIEW Origin and Evolution of the Great Lakes) 537; Tr. 1039:9-1041:18 (Larson); Pls.' Br. 26-27; PX 33 (1992 Pilot Study) 10 ("The harbor jetties . . . have effectively trapped some of the southerly littoral drift which has resulted in the sediment starved nearshore area to the south; sand cover, therefore, is not sufficient to protect the till from erosion."); Tr. 415:18-416:1 (Thompson); Def.'s Br. 6. The process by which the blockage of littoral drift causes erosion is explained generally in a review co-authored by Dr. Grahame J. Larson, one of defendant's experts:

> The [sediment] in the shorezone is . . . moved along the shore by waves and offshore currents in longshore transport (Lawrence 1994).
>
> However, two recent types of human intervention have seriously reduced the supply of [sediment] to the shore zone and facilitated the loss of [sediment] to deeper water: (1) dams on rivers that are tributary to the Great Lakes, and most importantly (2) jetties and other engineering structures at river mouths. The effects of damming tributaries is obvious – sediment settles out in the relatively still water of inland reservoirs and is not allowed to be transported to the Great Lakes shore. Jetties function differently. They are engineering structures erected at river mouths, resembling two long walls that border both sides of the river and extend from the river banks and mouth, just inland of a harbor, to relatively deep waters in the lake proper. Jetties affect beach replenishment by diverting sand and other sediments that move along the shore by lake processes, into deep water[14] . . . . [T]hese sediments can no longer be transported to the beach by waves and are therefore permanently lost from the beach system. For this reason, coastal erosion is often most severe near harbor structures, rather than at more "open" coasts. Dredging of river mouths for shipping and boating purposes can facilitate further transport of . . . sediment into deep water.

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[14]The emphasized words in Plaintiffs' Exhibit (PX) 101 (REVIEW Origin and Evolution of the Great Lakes) 537 are in dispute. Compare Tr. 1039:9-1041:18 (Larson) with Pls.' Br. 26-27. It is not disputed by either party that jetties divert sediment moving along the shore such that the sediment is removed from the littoral zone. See Pls.' Br. 26-27; Defendant's Post-Trial Brief (Defendant's Brief or Def.'s Br.) 6. Both parties also agree that at least some of that sediment is trapped against the jetties, but it is disputed whether some sediment moves to deep water. See Pls.' Br. iv; Plaintiffs' Response to Defendant's Post Trial Brief (Plaintiffs' Response or Pls.' Resp.) 12; Tr. 1171:8-11 (Nairn); see Part IV.C.2.c.

> Once the main source of [sediment] to the beach system, river mouths and harbors have now become sites of beach impoverishment. Thus, shoreline erosion or retrogression, a natural process, has been much more dominant than has shoreline progradation (Powers 1968), and should be considered, when development along the always-variable Great Lakes shorelines is contemplated.

PX 101 (REVIEW Origin and Evolution of the Great Lakes) 537 (citations omitted, emphasis added); Tr. 1039:9-1041:18 (Larson); Pls.' Br. 26-27. In other words, constant sediment transport acts as a source of sediment for the shoreline; when sediment transport is blocked, the shoreline downdrift cannot be replenished, and it recedes. Tr. 1039:5-8 (Larson) ("[I]f you block the littoral drift, the [sediment] keeps going in one direction and no re-supply comes from the other direction."); Pls.' Br. 26; PX 41 (Annual Report on the Section 111 Beach Nourishment Monitoring Program (1999 Report)) 3 ("At several of the older harbors, it is theorized that this long period of [sediment] removal from the littoral system may have created an enormous deficit in the [sediment] supply, triggering lake bed downcutting that may have contributed to the creation of areas of severe and continuing erosion."); Pls.' Br. 11; Tr. 436:15-437:16 (Thompson) (The jetties' "blocking [of] net littoral drift" results in "removal of material from the littoral system.").

The Corps released a series of reports (collectively, Corps Reports) over several decades describing the erosion caused south of St. Joseph Harbor by the jetties, outlining a plan to mitigate the erosion attributable to the jetties, and evaluating the effectiveness of the mitigation program that was eventually implemented. The Corps Reports were admitted into evidence as the following plaintiffs' exhibits: PX 132, titled "Berrien County, Michigan, Beach Erosion Control Study" (1958 Study); PX 93 (1973 Report); PX 22 (1974 Report); PX 94, titled "Effects of Breakwater Construction on Littoral Transport Along the State of Michigan Shoreline" (1983 Report); PX 32, titled "Interim Monitoring Report for St. Joseph Harbor, Michigan for the Period 1975-1984" (Interim Report 1975-1984); PX 33 (1992 Pilot Study); PX 114, titled "Coastal Engineering Technical Note" from 1992 (1992 Note); PX 23 (1996 Report); PX 24 (1997 Report); and PX 41(1999 Report).

The 1973 Report has been described, without contradiction, as "the first credible look at the St. Joseph Harbor structures in estimating the total amount of material trapped by the structures." Tr. 80:19-23 (Meadows). After the 1973 Report, the Corps implemented a mitigation program to reverse or slow down shoreline erosion. PX 24 (1997 Report) 5. The 1999 Report states, "The effectiveness of the . . . program is dependent on how well it duplicates the normal littoral processes." PX 41 (1999 Report) 3. In an attempt to duplicate the littoral process, the Corps' program tries to replace the sediment removed from the littoral system by the jetties. Tr. 180:1-4 (Chrzastowki).

The 1973 Report describes the remediation program, which comprises the creation of "feeder beaches" south of the harbor. PX 93 (1973 Report) 46. Material dredged from the harbor entrance and brought in from outside of the littoral system is placed on the feeder beaches in order to be dispersed into the littoral zone. See PX 93 (1973 Report) 49-50; Tr. 180:5-13 (Chrzastowki). This is to provide "annual nourishment equal to the amount of material [that] is interrupted or diverted into deep water." PX 93 (1973 Report) 46. The feeder beach located at Lions Park, immediately south of the harbor, Tr. 348:6-7 (Selegean), appears to be the main effort by the Corps at mitigation, see Defendant's Exhibit (DX) 34 (St. Joseph Dredging) 2 (indicating that most of the material placed in the littoral zone is placed at Lions Park), but there have been other temporary projects, see, e.g. Tr. 246:12-247:7 (Wineberg) (describing the Corps' 1976 feeder beach located on one of plaintiffs' properties); PX Summary Tab 4, 61; Pls.' Br. 14; Tr. 347:24-348 (Selegean) (testifying that "the initial quantities were to be split between three different nourishment sites"); PX 93 (1973 Report) 46.

In order to understand the the processes of sediment removal from the littoral system, to quantify the amount removed by the jetties, and to quantify the amount of sediment that needs to be replaced, scientists calculate a sediment budget, "[a]n accounting procedure to keep track along the shoreline of sediment inputs and sediment losses." Tr. 112:25-113:3 (Meadows). Therefore, an important step to implementing the mitigation program was to calculate the sediment removed yearly from the littoral system by the jetties. See Tr. 668:18-669:1 (Selegean). Because the net littoral drift was to the south, the authors of the 1973 Report calculated the longshore sediment transport rate by adding the amount of sediment trapped against the north jetty[15] to the amount of sediment that traveled around the north jetty and became trapped in the outer harbor,[16] which was ultimately dredged. See id.

In a study dated May, 2006, Dr. Nairn of W.F. Baird & Associates Limited provided his "Assessment of the Causes of Erosion in the Vicinity of St. Joseph Harbor, Michigan" (Nairn Report). DX 1 (Nairn Report). The Nairn Report is the basis of defendant's case and attempts to demonstrate that key features of the previous Corps Reports, particularly the 1973 Report, are in error. See generally DX 1 (Nairn Report);

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[15]The area next to a jetty that accumulates sediment is known as a "fillet." Tr. 44:10-14 (Meadows); Tr. 1250:15-17 (Nairn).

[16]The outer harbor is a flared area, Tr. 1250:22-24 (Nairn), just beyond the end of the jetties, see Tr. 331:4-19 (King); PX 116 (Record of Construction FY05 Maintenance Dredging St. Joseph Harbor, Michigan (2005 Record of Construction)); Tr. 334:1-11 (King).

Def.'s Br. passim; Def.'s Resp. passim. Critically important support to the Nairn Report is provided by a study by Dr. Larson of the Department of Geological Sciences at Michigan State University, explained in "Geology and Long-Term Lakeshore Erosion in the Vicinity of St. Joseph, Michigan" (Larson Report), dated May of 2006. See generally DX 3 (Larson Report); Def.'s Br. passim; Def.'s Resp. passim. Because the Corps Reports and testimony based on the Corps Reports form the foundation of most of plaintiffs' arguments, see generally Pls.' Br. passim; Pls.' Resp. passim; Pls.' Mem. passim, alleged errors in the Corps Reports are the main points of dispute in the case. These issues are summarized as follows:

1. The threshold issue is the extent of the zone that St. Joseph Harbor influences and whether that zone of influence includes plaintiffs' properties.[17] See infra Part IV.A.

2. Based primarily on several of the Corps Reports, plaintiffs argue that the kind of material used as nourishment is not proper for mitigation purposes and may, in fact, exacerbate erosion. Defendant, with support from Dr. Nairn and Dr. Larson, argues that the Corps Reports erred in concluding that the lake bottom and shore in the vicinity of plaintiffs' properties is not sandy. Thus, defendant argues, the Corps used appropriate nourishment for an area with a sandy geology. See infra Part IV.B.

3. The Nairn Report attempts to demonstrate that the sediment transport rate blocked by the jetties was improperly calculated by the 1973 Report and argues that the amount of sediment that needs to be replaced yearly is much lower than previously believed by the Corps and now asserted by plaintiffs. See infra Part IV.C.

4. Several of the Corps Reports cited by plaintiffs indicate that the location of the main feeder beach at Lions Park is problematic because the conditions in that area inhibit dispersal of much of the beach nourishment to plaintiffs' zone. The Nairn Report attempts to provide an explanation of the processes at Lions Park to support the assertion by defendant that it is an effective location for a feeder beach. See infra Part IV.D.

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[17]This issue was not argued by defendant. See Def.'s Br. passim; Defendant's Response to Plaintiffs' Post-Trial Brief (Def.'s Resp.) passim. The court believes that consideration of this issue is necessary, however, to its conclusions on the other issues.

III. Legal Authority

A. Takings Pursuant the Fifth Amendment

The Fifth Amendment of the United States Constitution provides that private property shall not "be taken for public use, without just compensation." U.S. Const. amend. V. "As its language indicates, and as the Court has frequently noted, this provision does not prohibit the taking of private property, but instead places a condition on the exercise of that power. . . . [I]t is designed . . . to secure compensation in the event of otherwise proper interference amounting to a taking." First English Evangelical Lutheran Church v. County of Los Angeles, 482 U.S. 304, 314-15 (1987); Narramore v. United States, 960 F.2d 1048, 1050 (Fed. Cir. 1992) (stating that the Fifth Amendment is a "tacit recognition of a preexisting power to take private property for public use" (quoting United States v. Carmack, 329 U.S. 230, 241 (1946)); Applegate I, 25 F.3d at 1581 ("The Amendment recognizes both the [f]ederal [g]overnment's right to take private property for public use and a property owner's right to just compensation."). When the government fails properly to compensate private property owners for a taking, this court has jurisdiction to enforce the owners' right to just compensation. Tucker Act, 28 U.S.C. § 1491; Applegate I, 25 F.3d at 1581.

Plaintiffs have misconstrued the focus of takings jurisprudence. Plaintiffs argue that the Corps "still think[s it has] an absolute right to swallow up private and public property without limit." Pls.' Mem. 11. The Corps does not have an absolute right to "swallow up private . . . property," but the limitation on this right is not on the amount of property "swallowed," but rather that the Corps owes compensation for the taking of property to which it had no prior rights. First English Evangelical Lutheran Church, 482 U.S. at 314-15; Narramore, 960 F.2d at 1050; Applegate I, 25 F.3d at 1581. Indeed, takings law has permitted entire parcels of property to be "swallowed up." See, e.g., Kelo v. New London, 545 U.S. 469 (2005) (upholding a ruling by the Supreme Court of Connecticut that a development agent be allowed to acquire plaintiffs' properties by eminent domain).

A recent case before the Supreme Court outlines in detail the requirement that private property be taken only for "public use." U.S. Const. amend. V. In Kelo, a city approved a development plan calling for the construction of a hotel, restaurants, stores, residences, state parks, and office space in order to revitalize the surrounding economically depressed area. 545 U.S. at 473-74. Despite the fact that the government passed much of the property it took into private hands, the Court upheld the lower court's ruling that the taking had been for a public purpose. Id. at 473, 490. The Court reasoned

that "a State may transfer property from one private party to another if future 'use by the public' is the purpose of the taking; the condemnation of land for a railroad with common-carrier duties is a familiar example." Id. at 477 (no citations in original). The public purpose requirement includes use of the taken property by the general public but is not confined to such use. Id. at 478-80 ("Nor will the private lessees of the land in any sense be required to operate like common carriers, making their services available to all comers."). The issue is whether the projected use of the taken land serves a "public purpose." Id. at 480. A purpose of creating an excess of 1,000 jobs, increasing tax and other revenues, and revitalizing an economically distressed city satisfied the "public purpose" requirement. Id. at 472, 490.

Plaintiffs' argument that "[t]he Constitution's public purpose justification for taking does not exist here because the commercial landings served by the large ships which require deep passageways are privately owned for profit – not public," Pls.' Mem. 5-6, is thus inapposite. The fact of private ownership of the ships that benefit from St. Joseph Harbor does not defeat the public purpose of the St. Joseph Harbor. Kelo, 545 U.S. at 490; PX 93 (1973 Report) 39 (the navigational structures create "national and regional economic development and . . . social well-being in the Southwestern Michigan area. The economic benefits received from the navigation project are principally the savings in transportation costs in the receipt of bulk commodities such as coal, petroleum products, cement, limestone, and sand and gravel."). It is undisputed that the purpose of the construction of St. Joseph Harbor was to aid navigation, Pls.' Mem. 5-6; Def.'s Mot. 5, and this court has discussed in a detailed opinion at an earlier stage in this litigation that the federal government has the power to improve navigable waterways, including the area of St. Joseph. Banks (scope) I, 68 Fed. Cl. at 531-32. The parties are bound by the law in that opinion and the court does not now revisit the question of the appropriateness of improvements on Lake Michigan and St. Joseph River for the purpose of navigation.[18] The court does not credit plaintiffs' arguments that "[t]he jetties do not create navigability," Pls.' Mem. 4, that "there is no navigational sovereignty," id. at 5, and that "[t]he three commercial landings in St. Joseph don't qualify for federal harbor status (and thus dredging) because they handle much less than the 1 million tons of cargo per year required." id. at 6. Plaintiffs never even attempt to reconcile their "public purpose" arguments with the fact that all of their claims rely on the Takings Clause of the Constitution, a clause which, the Supreme Court recently noted, "presupposes that the government has acted in pursuit of a valid public purpose." Lingle v. Chevron U.S.A., 544 U.S. 528, 543 (2005).

The Supreme Court has recognized that the government may take private property

[18]For an analysis of the law of the case doctrine, refer to footnote 6 in Part I.

either by physical invasion or by regulation. See Lucas v. S.C. Coastal Council, 505 U.S. 1003, 1014-15 (1992) (stating that the Fifth Amendment was interpreted to apply only to physical takings until 1922, when the Supreme Court stated that a regulation that "goes too far" will be recognized as a taking (citation omitted)). A physical taking occurs "when the government encroaches upon or occupies private land for its own proposed use." Palazzolo v. Rhode Island, 533 U.S. 606, 617 (2001); Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 426 (1982) (holding that "a permanent physical occupation authorized by the government is a taking"). Regulatory takings, on the other hand, occur "when government action, although not encroaching upon or occupying private property, still affects and limits its use to such an extent that a taking occurs." Cienega Gardens v. United States, 265 F.3d 1237, 1244 (Fed. Cir. 2001) (citations omitted). Defendant is correct in stating that, in many aspects, "[t]he liability considerations differ markedly for these two categories, and it is 'inappropriate to treat cases involving physical takings as controlling precedents for the evaluation of a claim that there has been a 'regulatory taking,' and vice versa.'" Def.'s Resp. 2 (citing Tahoe-Sierra Preservation Council, Inc. v. Tahoe Regional Planning Agency, 535 U.S. 302, 323 (2002); Casitas Mun. Water Dist. v. United States, 76 Fed. Cl. 100, 105 (2007)). It is undisputed that an alleged taking by erosion falls under the category of a physical taking, see, e.g., Boling v. United States, 220 F.3d 1365, 1373 (Fed. Cir. 2000); Applegate v. United States (Applegate II), 35 Fed. Cl. 406 (1996), and thus plaintiffs' extensive reliance on regulatory takings cases to argue that there be a nexus and proportionality between plaintiffs' property losses and navigation is inapposite, Def.'s Resp. 2 (citing Pls.' Br. 35-36 (citing Dolan v. Tigard; 512 U.S. 373 (1994); Nollan v. Cal. Coastal Comm'n, 483 U.S. 825 (1987))); Pls.' Mem. 5.

The Federal Circuit explains in relevant part that, to argue a taking successfully, be it regulatory or physical, "a property owner must prove that the asserted government invasion of property interests allegedly effecting a taking . . . was 'the direct or necessary result' of the act" or "within contemplation of or reasonably to be anticipated by the government." Vaizburd v. United States, 384 F.3d 1278, 1282-83 (Fed. Cir. 2004) (citation omitted); Applegate II, 35 Fed. Cl. at 413-14. Implicit in this test is that, before a plaintiff can pursue a takings claim against the United States, he or she must first prove ownership of the property allegedly taken. See Air Pegasus of D.C., Inc. v. United States, 424 F.3d 1206, 1212 (Fed. Cir. 2005); Wyatt v. United States, 271 F.3d 1090, 1096-97 (Fed. Cir. 2001), cert. denied, 535 U.S. 1077 (2002). "In a physical takings case, the inquiry is limited to whether the claimant can establish a physical occupation . . . of his property by the Government." Applegate II, 35 Fed. Cl. at 414 (citing Loretto, 458 U.S. at 441). Physical injury to real property substantially contributed to by a public improvement suffices to establish physical occupation. Loretto, 458 U.S. at 441. Erosion of property due to government action is one example of physical injury that rises to the

level of a taking. See, e.g., Boling, 220 F.3d at 1373; Applegate II, 35 Fed. Cl. at 414.

For reasons of efficiency, the court has left the questions of specific property ownership and damages to be determined after trial of causation. Banks Pretrial Transcript (Pretrial Tr.) 174:5-176:2.[19] The parties do not dispute that St. Joseph Harbor causes erosion and that erosion has occurred in the area of plaintiffs' zone. Pls.' Br. 26-27; Def.'s Br. 6. The disputed issue in this case, therefore, is whether the government's actions effectively offset the effects of St. Joseph Harbor on plaintiffs' zone such that the erosion in plaintiffs' zone is not attributable to the government.

B. Burden of Proof

Defendant is correct in stating that "[p]laintiffs bear the burden of proof in civil proceedings." Def.'s Br. 5. Plaintiffs meet that burden only if they establish by a preponderance of the evidence the cause of action for which they have sued. The United States Court of Appeals for the Federal Circuit has "defined preponderance of the evidence in civil actions to mean 'the greater weight of evidence, evidence which is more convincing than the evidence which is offered in opposition to it.'" Jazz Photo Corp. V. United States, 439 F.3d 1344, 1350 (Fed. Cir. 2006) (citing Hale v. Dep't of Transp., Fed. Aviation Admin., 772 F.2d 882, 885 (Fed. Cir. 1985); see also St. Paul Fire & Marine Ins. Co. v. United States, 6 F.3d 763, 769 (Fed. Cir. 1993) (same).

C. Admissions and Expert Testimony

The Federal Rules of Evidence (FRE) make admissible for the truth of the matter asserted admissions made by party-opponents. See Fed. R. Evid. 801(d)(2). Admissions by a party-opponent are an exception to the general prohibition on hearsay, defined as "a statement, other than one made by the declarant while testifying at the trial or hearing, offered in evidence to prove the truth of the matter asserted." Id. at 801(c). Specifically, the statement must be offered against a party and must fall into one of the following categories: 1) the statement is the party's own statement in either an individual or representative capacity; 2) the statement is one of which the party has manifested an adoption or belief in its truth; 3) the statement was made by a person authorized by the party to make a statement concerning the subject; or 4) the statement is one by the party's agent or servant concerning a matter within the scope of the agency or employment, made

[19]Arguments from plaintiffs about the scope of damages, therefore, are inapposite. See, e.g., Pls.' Br. 36-37.

during the existence of the relationship. Id. at 801(d)(2).[20] Therefore, an out-of-court statement of a party-opponent offered for its truth is admissible at trial providing that it conforms with Federal Rule of Evidence 801(d)(2).

The following exhibits, consisting in the main of the Corps Reports that form the basis of plaintiffs' arguments, constitute admissions under FRE 801(d)(2) because they meet the requirements of that rule: PX 132 (1958 Study); PX 93 (1973 Report); PX 22 (1974 Report); PX 94 (1983 Report); PX 32 (Interim Report 1975-1984); PX 33 (1992 Pilot Study); PX 114 (1992 Note); PX 23 (1996 Report); PX 24 (1997 Report); PX 41(1999 Report); PX 96[21] (Corps Finding of No Significant Impact); and PX 113, titled "Great Lakes Coastal Geology and Coastal Engineering, Southeastern Lake Michigan 30 April 1994" (1994 Site Visit).[22] First, the exhibits were offered by plaintiffs in evidence to prove the truth of the matter asserted, that is, to prove the truth of the statements that the reports themselves contain. Second, plaintiffs offered those documents against its party-opponent, defendant. Finally, the statements contained in these documents qualify as defendant's own statements because they are reports issued by the United States. The studies not issued directly by an agency of the United States and instead issued by a

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[20]A fifth category relating to statements of co-conspirators has been omitted from this discussion as irrelevant. See Fed. R. Evid. 801(d)(2).

[21]Plaintiffs' Exhibit 96 consists of two documents, a title page to a Corps document titled "Finding of No Significant Impact" and a document titled "Glacial Tills Under Lake Michigan" by the Illinois State Geological Survey in 1974. See PX 96. Although Dr. Nairn did not seem to be familiar with the document, in examining PX 96, Dr. Nairn appeared to distinguish the two documents by describing the section entitled "Glacial Tills Under Lake Michigan," which was "[a]side from the cover page." Tr. 1267:9-15 (Nairn). This cover page is the Corps document, "Finding of No Significant Impact." PX 96. The court has not found a connection between those two documents on their face or in the testimony, see id.; Tr. 1267:9-15 (Nairn), and therefore distinguishes them in its citations as follows: PX 96 (Corps Finding of No Significant Impact) and PX 96 (Illinois State Geological Survey). This distinction is relevant in that the former could constitute, if relevant to the case, an admission by defendant, whereas the latter cannot be ascribed to defendant.

[22]Plaintiffs' Exhibit 113 is divided into two sections, "Itinerary - Day 1" and "Itinerary - Day 2," both numbered independently. See PX 113 (Great Lakes Coastal Geology and Coastal Engineering, Southeastern Lake Michigan 30 April 1994 (1994 Site Visit)). When relevant, this Opinion will specify which section it is referring to.

Plaintiffs' Exhibit 113 is a guide to a site visit in 1994. Tr. 451:14-16 (Thompson) (citing PX 113 (1994 Site Visit)). The Corps sponsored the site visit. Id. at 457:2-4 (Thompson) (citing PX 113 (1994 Site Visit)).

private entity hired by the government for the purpose of studying and submitting a report on the erosion at St. Joseph qualify as statements made "by a person authorized by the party to make a statement concerning the subject." Fed. R. Evid. 801(d)(2)(C). Evidence that qualifies as a statement by an authorized person but does not qualify as an admission (because it is not offered by a party-opponent) includes the backbone of defendant's arguments, the Nairn Report, DX 1(Nairn Report), and the supporting report by Dr. Larson, DX 3 (Larson Report). See Fed. R. Evid. 801.

Both the Nairn Report and the Larson Report were admitted into evidence as expert reports. Tr. 1151:9-14, 1020:15-17; see also Banks v. United States (Banks (expert report)), 75 Fed. Cl. 294, 304 (2007) (refusing to strike Nairn Report). The court did so under the authority of FRE 702, which enables the trier of fact to rely upon the testimony of an expert with scientific, technical, or other specialized knowledge. Fed. R. Evid. 702. Specifically, FRE 702 states:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

Id. The Supreme Court has held that the trial court acts as a "gatekeeper" under FRE 702 to "'ensur[e] that an expert's testimony both rests on a reliable foundation and is relevant to the task at hand.'" Kumho Tire Co. v. Carmichael, 526 U.S. 137, 141 (1999) (Kumho Tire) (quoting Daubert v. Merrell Dow Pharms. Inc., 509 U.S. 579, 597 (1993)). The trial court's gatekeeping duty extends to all expert testimony, whether it be scientific, technical, or another type of specialized knowledge. Kumho Tire, 526 U.S. at 147. The rationale underlying the gatekeeping requirement is "to make certain that an expert, whether basing testimony upon professional studies or personal experience, employs in the courtroom the same level of intellectual rigor that characterizes the practice of an expert in the relevant field." Id. at 152.

Plaintiffs moved in November 2006 to exclude the Nairn Report and the expected testimony at trial of Dr. Nairn, see Plaintiffs' Motion to Strike Dr. Nairn's Expert Report of Nov. 20, 2006, but, after responsive briefing by defendant and subsequent oral argument, the court denied the motion, Banks (expert report), 75 Fed. Cl. at 304. Further, during trial, the court qualified Dr. Nairn as an expert in a variety of areas related to the

central issues of the case. Tr. 1107:22-24 (Nairn).[23]

During trial and in briefing, plaintiffs attack the credibility of the Nairn Report because it is the work of Dr. Nairn and does not reflect the thinking of others involved, as Dr. Nairn was, in the preparation of the Corps Reports. When discussing the extent of the zone of influence of the jetties, for example, plaintiffs note that "[a]ll three of the authors of . . . PX 113 . . . attended the PX 33" workshop and that Mr. Larry Parson, co-author of PX 113, also co-authored the 1996 Report and the 1997 Report. Pls.' Br. 2; PX 113 (1994 Site Visit); PX 23 (1996 Report); PX 24 (1997 Report). Plaintiffs also state that the organizations associated with the creation of the Corps Reports, as well as some of their authors, "are not shown to have joined with Dr. Nairn in his May 2006 litigation report." Pls.' Br. 2-3; PX 113 (1994 Site Visit); PX 23 (1996 Report); PX 24 (1997 Report). Plaintiffs point to the $1,000,000 in expert fees paid to Dr. Nairn by defendant. Pls.' Br. 3 (citing Tr. 1327:1-18 (Nairn)). Plaintiffs' reference to Dr. Nairn's fee and the fact that he conducted his research on the Nairn Report without the collaboration of other authors of the Corps Report appear intended to suggest that Dr. Nairn's expert report is an about-face by a lone scientist whose opinion has been bought and paid for.

Dr. Nairn's report and testimony have been admitted into evidence by the court as an expert report and expert testimony. Tr. 1107:22-24 (Nairn); see also Banks (expert report), 75 Fed. Cl. at 304. The fact that previous Corps Reports, some co-authored by Dr. Nairn, see, e.g., PX 23 (1996 Report); PX 24 (1997 Report), are admissions by defendant is also not in dispute and defendant's counsel acknowledged this as to the 1973 Report specifically. Tr. 74:23-75:25 (Petrie, defendant's counsel). What is at issue, therefore, is the credibility of an expert's report and testimony when compared with prior admissions by a defendant.

The court does not view the admissions as ipso facto more credible than the Nairn Report because they are prior statements by defendant. Neither does the court hold the Nairn Report in higher regard than the admissions because Dr. Nairn is a qualified expert witness. The court instead reviews the evidence that both parties put before it and determines, based on the substance of the evidence and any surrounding facts and

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[23]As noted above in footnote 11 of Part I, both parties qualified several witnesses as experts. Defendant submitted the expert reports of these witnesses into evidence. See, e.g., Defendant's Exhibit (DX) 3 (Geology and Long-Term Lakeshore Erosion in the Vicinity of St. Joseph, Michigan (Larson Report)). The court explicitly inquired, with respect to plaintiffs' first expert witness to testify, Dr. Meadows, as to whether plaintiffs would like to move for the admission of his expert report. Tr. 163:6-11. Plaintiffs did not submit any of their experts' reports into evidence. See Tr. passim.

circumstances tending to make the evidence more or less pertinent or credible, which party presents the more persuasive argument on a particular substantive issue. Among the surrounding facts and circumstances are the increasing sophistication of methods of study of littoral processes and the sharper focus of the expert reports on the issues in this case as compared to the more general focus of the Corps Reports.

The court directed the parties that documentary evidence should be explained to the court at trial:

> [T]he parties are advised that the court expects documentary evidence to be presented through and explained to the court by expert and/or percipient witnesses. Accordingly, the court will include the following in its pretrial order: "Any exhibit and/or any portion of an exhibit the import of which with respect to one or more issues in the case is not specifically pointed out by a witness at trial may be disregarded by the court in its determination of the case. 'Specifically pointed out' means specific mention, with reference to an exhibit number, and to one or more specific page numbers within, or otherwise identifiable portion of, the exhibit, together with an indication of how the evidence supports or disproves a fact in issues. 'Specifically pointed out' shall not include mention for the first time in post-trial briefing.

Order of Jan. 19, 2007, 3; Order of Apr. 19, 2007, 2-3. This case involves several key technical issues and the court necessarily relies on the assistance of witness testimony to understand those issues. In particular, the court relies on witness testimony for assistance in discerning the impact of the many technical documents in evidence.

Plaintiffs disregarded the court's Order of April 19, 2007, and presented for the first time in their post-trial briefing many sections of exhibits that were not "specifically pointed out at trial" or that were pointed out for an apparently different purpose than the purpose advanced in post-trial briefing. See Pls.' Br. passim; Pls.' Resp. passim. Given that most of the exhibits so used in plaintiffs' briefing were admitted into evidence as admissions by a party-opponent, and given that the court's Orders of January 19, 2007, and April 19, 2007, allowed the court discretion to consider such evidence, the court affords plaintiffs the benefit of what the court views as straightforward admissions. Similarly, the court occasionally refers to sections of documentary evidence that were neither discussed at trial nor in briefing, but that the court understands to be straightforward. However, many of the issues are of a sufficiently technical nature that the explanation of an expert with "scientific, technical, or other specialized knowledge," Fed. R. Evid. 702, is required for proper interpretation. Without expert assistance, the court will not reach conclusions on evidence that is beyond its non-expert ability to

interpret, nor will it consider post-trial briefing that effectively amounts to testimony from plaintiffs' counsel in interpreting such evidence. See Fed. R. Evid. passim (outlining rules concerning the admission and use of evidence from witness testimony, exhibits, certain hearsay exceptions, and judicial notice, but not authorizing the admission of testimony contained in briefing from counsel who is not a witness).

IV. Analysis

A. Zone of Influence of Navigational Structures

The 1973 Report identified the zone affected by the piers to extend "from the foot of Park Street in St. Joseph southerly along the Lake Michigan shoreline for a distance of approximately 18,400 feet. South of this area, the average littoral drift approximates the rate of littoral drift north of the piers, and therefore, is not affected by the navigation works." PX 93 (1973 Report) 58; Tr. 376:4-9 (Selegean). These parameters do not include most of plaintiffs' properties. Tr. 380:22-381:8 (Selegean); DX 1 (Nairn Report) 3, Fig. 1.1; Def.'s Br. 2 n.1. However, plaintiffs argue that the zone of influence "is not to be considered fixed," Pls.' Resp. 2, citing a Corps Report that states, "Topographic maps of the 'zone of influence', . . . should be developed annually based on aerial photogography," PX 32 (Interim Report 1975-1984).[24] Government documents subsequent to the 1973 Report but prior to the initiation of this litigation included most of plaintiffs' properties in this zone of influence.[25] PX 33 (1992 Pilot Study) 23;[26] Tr. 50:12-13, 52:5-7 (Meadows); Tr. 413:3-4 (Thompson); Pls.' Br. 1; PX 33 (1992 Pilot Study) 6 ("[S]ignificant erosion has occurred south of St. Joseph . . . harbor jetties which are barriers to the southerly littoral drift. . . . A detailed lake bottom difference map for the

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[24]This excerpt was not specifically pointed out or discussed at trial. See Tr. passim.

[25]Plaintiffs refer to page 10 of the 1992 Pilot Study as support for the assertion that the zone of influence was extended beyond the initial calculations of the 1973 report. Plaintiffs' Opening Post Trial Brief, filed July 6, 2007 (Pls.' Br.), 1 (citing PX 33 (Preliminary Results of a Pilot Study Conducted Between St. Joseph, Michigan and Michigan City, Indiana (1992 Pilot Study)) 10). The reference states, "The harbor jetties to the north of [Shoreham] have effectively trapped some of the southerly littoral drift which has resulted in a sediment starved nearshore area to the south," resulting in erosion. PX 33 (1992 Pilot Study) 10. No witnesses discussed this excerpt in this context and it is unclear to the court that it supports plaintiffs' contention. See Tr. 479:7-13 (Thompson); Tr. 1047:23-1048:2 (Larson); PX 33 (1992 Pilot Study) 10.

[26]There are two sets of page numbers in PX 33 (1992 Pilot Study) . This Opinion uses the set in smaller type, following testimony of plaintiffs' witnesses' example at trial. See, e.g., Tr. 51:13-14 (Meadows).

area between St. Joseph and Grand Mere State Park (fig. 11) shows the amount of erosion of the lake floor in an area where severe coastal bluff erosion (Buckler, 1981) has occurred.") (emphasis added).[27] Plaintiffs argue that, at least by 1994, when the Corps in conjunction with the Coastal Engineering Research Center conducted a series of site visits along southern Lake Michigan, Tr. 451:14-24 (Thompson), the Corps included plaintiffs' properties within the area influenced by the harbor. Indeed, PX 113 (1994 Site Visit), which describes the site visit, states that it "will focus on the reach of coastline under the influence of the federally maintained navigation structures at St. Joseph/Benton Harbor." PX 113 (1994 Site Visit Day 1) 2; Pls.' Br. 1. The site visit extended "from about two miles north of St. Joseph to the vicinity of Grand Mere Lakes." PX 113 (1994 Site Visit Day 2) 2; Tr. 454:10-455:14 (Thompson);[28] Pls.' Br. 1. Plaintiffs refer to calculations made by Dr. Meadows that the lake bed south of the jetties is undergoing down-cutting at an average of 3.5 inches per year. Tr. 53:18, 54:23-25 (Meadows) (citing PX 33 (1992 Pilot Study) 23);[29] Pls.' Br. 3. Plaintiffs include an excerpt from Dr. Meadows' testimony where he states that "if the sediment is continued, not to be supplied from the north, then the length of the area that is eroding will continue to expand." Tr. 54:18-20 (Meadows); Pls.' Br. 3.

Although defendant points out that some studies did not include data from the area of plaintiffs' properties, Def.'s Br. 23; Def.'s Resp. 9 n.5, defendant does not refute the assertion that the jetties' influence extends to plaintiffs' properties. Def.'s Br. passim; Def.'s Resp. passim.[30] In fact, defendant's entire defense is argued as if mitigation of all

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[27]This excerpt was not specifically pointed out or discussed at trial. See Tr. passim.

[28]Mr. Thompson testified that the zone of influence extended at least as far as Shoreham, but not as far as the Warren Dunes, Tr. 454:10-455:14 (Thompson), contradicting plaintiffs' assertion that "PX 113-2 . . . extends this definition [of the zone of influence] to the Warren Dunes on the south," Pls.' Br. 1.

[29]A possible inference from the testimony is that all of the 3.5 inches per year are caused by the jetties, but this is never explicitly stated and it is not certain that some background erosion is not included in the figure. See generally Tr. 50:12-55:1 (Meadows).

[30]Plaintiffs erroneously assume that defendant adopts the zone of influence described in the 1973 Report. See Pls.' Resp. 2 (citing Def.'s Br. 2). However, defendant provided that figure as background to the current litigation rather than as a reflection of its position. Similarly, in the same paragraph in which defendant discusses the zone of influence according to the 1973 Report, it states that the 1973 Report calculated the net longshore transport rate at 110,000 cubic yards per year, Def.'s Br. 2, also a statement provided as background because the 110,000 cubic yards figure is clearly at odds with defendant's litigation position on the net longshore transport

of plaintiffs' zone is necessary. See Def.'s Br. passim; Def.'s Resp. passim. Dr. Nairn, defendant's key witness, included all of plaintiffs' properties in his study area. DX 1 (Nairn Report) 3, Fig. 1.1.

The court concludes that the zone of influence of St. Joseph Harbor includes plaintiffs' properties. Although not specifically pointed out by plaintiffs, the court views the most persuasive evidence to be contained in the 1958 Study, an admission by defendant. The 1958 Study had a different focus than the 1974 Report. As explained by Dr. Selegean,

> The distinction was this older study, the 1958 [Study] . . . was proposing to build a large berm to act as shore protection and then to nourish it every year with enough material so that as it eroded that it would remain intact and would continue to protect the properties behind it. Whereas, the [1973 Report], its goal was to address erosion attributable to the harbor, to mitigate the erosion attributable to the harbor.

Tr. 670:19-671:1 (Selegean).

Even though the focus of the 1958 Study was not to assess erosion from the St. Joseph Harbor specifically, it nevertheless recognized that erosion was attributable to the harbor structures and their maintenance. The 1958 Report covered "a portion of the shore of Berrien County about 32 miles in length from the north city limit of Benton Harbor to the Michigan-Indiana State line," PX 132 (1958 Study) 3, an area that includes plaintiffs' zone, DX 1 (Nairn Report) 3, Fig. 1.1. The 1958 Report clearly admits, "The navigation channel at St. Joseph Harbor is dredged annually to maintain project depth, and for this reason little or no beach building material is believed to pass the harbor entrance and reach the downdrift shore." Id. at 4. The 1958 Report concludes, however, that an area "to the south limit of the village of Shoreham," id. at 44, which includes plaintiffs' zone, DX 1 (Nairn Report) 3, Fig. 1.1, should not receive federal aid for shore protection against erosion because it is "entirely privately owned" and this funding "would have no public benefits," PX 132 (1958 Study) 44. Nevertheless, the study admits that "this reach . . . would receive substantial benefits of shore stabilization due to restoration of normal littoral drift." Id. The study recognizes that there are several factors that disrupt the "normal littoral drift," and it does not apportion the amount of disruption among the factors. See id. at passim. The court deems the recognition in the 1958 Study that St. Joseph Harbor is one factor causing increased erosion and the inclusion in the 1958 Study of plaintiffs' zone within the zone where the "normal littoral drift" has been interrupted,

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rate, Def.'s Br. 13-14; Tr. 1144:9-22 (Nairn).

together with later Corps Reports that attribute 30% of the total erosion south of St. Joseph Harbor to the jetties, PX 93 (1973 Report) 32; PX 22 (1974 Report) 235; PX 41 (1999 Report) 4; Tr. 655:16-21 (Selegean) ("[Thirty] percent of that total erosion the author claims [316,000 cubic yards per year] is due to the harbor.") (citing PX 93 (1973 Report) 32), to constitute an admission by the Corps that plaintiffs' properties have been considered in the zone of influence of the jetties at least as far back as the 1950s, even if the specific impact of the jetties was not quantified until later.

B. Adequacy of Nourishment Material

1. Composition of the Lake Bed

Sediment comprising a lake bed can be divided roughly into two categories: cohesive and sandy. "[A] cohesive lake bottom refers to [a] bottom [where] materials are held together such that they are not freely mobile. . . . [I]t could be broken up but is going to take more energy." Tr. 198: 10-15 (Chrzastowki). The 1996 Report described cohesive sediment as "more erosion-resistant (yet erodible)." PX 23 (1996 Report) 48. A sandy bottom, on the other hand, is composed of "material that can easily be dispersed with minimal effort." Tr. 198: 12-13 (Chrzastowki). "Glacial till is cohesive material." Tr. 198: 18 (Chrzastowki).[31] Till is an "all-encompassing name" that refers to a variety of materials, including compact silt, clay, and pebbles. Tr. 176:22-25 (Chrzastowski).

The composition of the lake bed is relevant because the composition affects erosion and mitigation processes. If the shore[32] is composed of sand, the quantity of sand

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[31]Occasionally, "in the evolution of the lake the glaciers stripped all of the pre-existing material all the way to bedrock." Tr. 198:24-199:1 (Chrzastowki).

[32]"Shore" is defined in common usage as "[t]he land along the edge of an ocean, sea, lake, or river; a coast." American Heritage Dictionary 1610 (4th ed. 2000). For the most part, witnesses appeared to use this definition. See, e.g., Tr. 190:6-10 (Chrzastowski). However, both parties' experts also used the term "shore" to mean the lake bottom or lake bed close to the edge of Lake Michigan, for example, in the following colloquy between plaintiffs' counsel and Dr. Chrzastowski:

Q: [I]s it logical to assume that that amount of erosion will continue to move to the south . . . ?

A: . . . . [I]f the sediment is continued, not to be suppled from the north, then that length of area that is eroding will continue to expand because the only source is eroding of the bottom once the sediment supply from both the north and from the shoreline is shut off.

Q: And this phenomena of erosion, is that – does it go by another name in the case of

that is depleted is directly proportional to the quantity of sand that needs to be replaced. Tr. 1215:11-16, 1296:4-10 (Nairn) ("[F]or a predominately sandy shore . . . as long as the sand supply south of the harbor is restored to the pre-harbor levels, then we can assume directly that the erosion will remain the same as the pre-harbor levels, all other things aside . . ."). "[I]t's the sand that stays on the shore and builds the beaches." Tr. 1214: 20-21 (Nairn). In Dr. Nairn's words, "it's a simple sediment budget" and a "simpler assessment." Tr. 1215:12, 8 (Nairn). Plaintiffs do not point to any evidence that would refute this assessment of the processes with respect to a sandy shore. See Pls.' Br. passim; Pls.' Resp. passim.[33]

In contrast, "cohesive shores [are] much more complicated." Tr. 1215:15-18 (Nairn). "We know the sand acts to abrade, sort of like sandpaper, the till. And it also acts to protect it . . . . It doesn't allow it to be eroded." Tr. 1215:23-25 (Nairn). Dr. Nairn testified that, in attempting to mitigate by replacing the sand cover that should protect the till from erosion, "[t]here's no scientific knowledge as to . . . when you increase your erosion and when you may decrease your erosion." Tr. 1216:2-5 (Nairn). Plaintiffs' experts provided testimony consistent with Dr. Nairn's testimony. Dr. Michael John Chrzastowski testified that if the sand cover to glacial till is depleted, the energy of the waves and the shifting of the sand, which acts as "sandpaper," can cause the lake bottom to erode and thus lower in a process referred to as "downcutting." Tr. 176:15-178:14 (Chrzastowki). Dr. Meadows explains this process as occurring when the sediment supply from upstream and from the shore is cut off: "[T]he only source is eroding of the bottom." Tr. 54:18-22 (Meadows).

There is also evidence that "what's critical about till downcutting is it's referred to as non-reversible erosion. Once it erodes, it does not recover." Tr. 178:12-14 (Chrzastowki); PX 23 (1996 Report) 10 ("The sand cover may come and go (depending on the season, water level, and storm activity), but erosion of the cohesive layer is irreversible. . . . Once this material is eroded by waves, it cannot reconstitute itself, and the cohesive form is lost forever."); PX 24 (1997 Report) 8 ("[E]rosion of the cohesive layer is irreversible."); PX 41 (1999 Report) 3. Defendant points to no evidence that refutes its prior admissions concerning the permanency of erosion of a cohesive shore.

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cohesive shores?

A: Lakebed downcutting is another term that is used to express this phenomena.

Tr. 54:11-55:1 (Chrzastowski) (emphasis added); see also Tr. 1215:4-1216:4 (Nairn).

[33]This is consistent with plaintiffs' position, as explained in this Part IV.B.I, that the lake bottom comprises cohesive material and not sand.

Def.'s Br. passim; Def.'s Resp. passim. Dr. Nairn in testimony does express uncertainty about the effect of placing sand on a cohesive shore to the effect that nourishment might protect a cohesive shore from further erosion or nourishment might exacerbate erosion. Tr. 1215:23-1216:10 (Nairn). However, defendant does not highlight this uncertainty in briefing, see Def.'s Br. passim; Def.'s Resp. passim, and, in any event, it is not inconsistent with evidence that erosion of a cohesive shore may not be reversed.

Lake bottom down-cutting deepens the water and steepens the offshore profile, Tr. 106:19-20 (Meadows), that is, it steepens the slope of the shore, Tr. 1224:3-14 (Nairn). Steepening of the profile allows larger waves to reach closer to the shoreline, thus increasing erosion rates downdrift. Tr. 106:18-107:1 (Meadows); see Tr. 1224:3-17 (Nairn).

In a paragraph near the conclusion of Plaintiffs' Brief, plaintiffs appear to identify for the first time the issue of the composition of the lake bottom. See Pls.' Br. 28. Plaintiffs' argue that "the weight of the evidence shows the lake bed in [plaintiffs' zone] to be glacial till." Pls.' Br. 29. Dr. Chrzastowki testified that to the extent of his knowledge the lake bottom at plaintiffs' zone is all composed of glacial till, without any exposure of bedrock. Tr. 199: 6-11 (Chrzastowki); Pls.' Br. 28.[34] The 1996 Report also

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[34]Plaintiffs rely on the statement in the Illinois State Geological Survey that an area including plaintiffs' zone has an underlying lake bottom of Wadsworth till. PX 96 (Illinois State Geological Survey) 10; Pls.' Br. passim; Pls.' Resp. passim. Plaintiffs' Exhibit 96 (Illinois State Geological Survey) was called to the attention of Dr. Nairn during cross-examination. Tr. 1267:9-1268:4 (Nairn). However, Dr. Nairn did not appear familiar with the document and did not testify as to its authorship, methodology, or conclusions. Id. No other witness discussed PX 96 (Illinois State Geological Survey), let alone authenticated it in any way. See Tr. passim. For the following reasons, the court cannot consider the Illinois State Geological Survey as an impeachment of Dr. Nairn's testimony or otherwise as evidence in this case.

Although admissible as a public document, Fed. R. Evid. 803(8), the technical topic of "glacial tills," PX 96 (Illinois State Geological Survey) cover (capitals omitted), qualifies this evidence as a possible learned treatise. See Fed. R. Evid. 803(18). A "learned treatise" is "[a] treatise, periodical, or pamphlet on the subject of history, medicine, or other science or art . . . if it has been established as a reliable authority by the testimony of the expert who relied upon it or to whose attention it was called." Matthew Bender 1-6 Fed. Evid. Practice Guide § 6.06(18). "When statements from a learned treatise are admitted into evidence, they may be read to the finder of fact, but the statements themselves may not be admitted as documentary evidence unless they are admissible under some other exception to . . . the hearsay rule." Id. Statements in a learned treatise are admissible under FRE 803(18) "to the extent they have been relied upon by an expert witness in the formulation of his . . . direct testimony or if they have been called to his .

describes glacial till in the Lake Michigan lake bed. PX 23 (1996 Report) 7; Tr. 1266:6-1267:3 (Nairn).

> Wadsworth Till . . . forms the consolidated lake bed of the southern and southeastern parts of Lake Michigan and underlies the younger non-till sediments. . . . This formation covers the lake bottom at a thickness of up to 18 m (60 ft) at depths below 30 m. At shallower depths, a veneer of sand and gravel overlie the Wadsworth Till. In some areas, the veneer may be absent, exposing the underlying till. The till is about 15-30 m thick and overlies bedrock . . . . It is common for the underlying bedrock to become exposed.

PX 23 (1996 Report) 7 (citations omitted); Tr. 1266:6-1267:3 (Nairn). There is no testimony in the record that explains, for example, whether the "lake bottom" described in the 1996 Report as till is the same as the material formed between the shoreline and the water depth of closure adjacent to plaintiffs' properties. See Tr. passim. Plaintiffs also point out that the Corps admitted in relevant part in 1994 that, except for "several small outcroppings of shale in the offshore region of Berrien County and a large outcrop occurring near Lakeside . . . . [e]verywhere else, the bedrock is covered with a blanket of glacial drift and unconsolidated lacustrian and aeolian sediments." PX 113 (1994 Site Visit Day 1) 2; Tr. 455:1-8 (Thompson); Pls.' Br. 28; see also PX 23 (1996 Report) 48 (stating that St. Joseph exhibits "[a] cohesive sediment substratum," determined using data from GPR, visual inspection, and actual sampling);[35] PX 24 (1997 Report) 1, 3-8.

. . attention during cross-examination." Id. "Once the expert witness has recognized that the publication is authoritative, it is appropriate to cross-examine the expert with regard to statements it contains. It is equally appropriate to cross-examine an expert witness with statements from a publication he or she does not recognize, so long as the publication has been previously established as authoritative by the testimony of another expert in the field or by judicial notice." Id. Regarding impeachment, "it is not a sufficient establishment of a book as a reliable authority to attempt to impeach an expert witness by asking him or her to admit that he or she has not read it. Both the impeachment and the establishment of the prerequisite fact for admissibility will succeed if the expert witness first admits the book is an authoritative text; absent the admission or the establishment of the book's authoritative status through another expert witness or judicial notice, neither succeeds." Id.

[35]As further evidence of the composition of the lake bottom, plaintiffs identify pictures they have taken. Pls.' Br. 30 (citing PX Summary Tab 1, 34-35, 39-40). Ms. Ehret identified these pictures and testified that the object in pictures 34 and 35 "is a piece of clay," a kind of material that she did not see before 2005 because now "the lakebed is gone." Tr. 754:5-21 (Ehret); PX Summary Tab 1, 34-35. As noted below in footnote 75, Part IV.E.1, the court accepts Ms. Ehret's testimony as a fact witness and considers that material began appearing on

Similarly, the depth at which the cohesive sediment substructure is found, is not set out in the 1997 Report. PX 24 (1997 Report) passim.

Plaintiffs also argue that lake bed lowering and down-cutting associated with the presence of glacial till (as distinguished from sand) are the same phenomenon, citing to several experts in support. Pls.' Br. 29 (citing Tr. 461:1-3 (Thompson); Tr. 54:25-55:6 (Meadows)). Mr. Charles Lyle Thompson testified that lake bed lowering and down-cutting are the same thing. Tr. 461:1-3 (Thompson). Dr. Meadows explained that when the sediment supply from updrift and from the shoreline is shut off by the jetties and by shoreline protection respectively, the only source of sediment for the littoral drift is the lake bottom, which will therefore erode. See Tr. 54:18-24 (Meadows); Pls.' Br. 29. He further testified that erosion of the lake bottom is the same thing as down-cutting. Tr. 54:25-55:6 (Meadows). Plaintiffs point out that Dr. Nairn admitted that a total barrier updrift would cause sand to be lost and, with a sandy shore, the result would be a lowering of the lake bed "with or without downcutting[,] and with or without glacial till." Pls.' Br. 29 (citing Tr. 1295:12-16 (Nairn) (emphasis omitted). It appears to the court that plaintiffs are arguing in the alternative that, even if the lake bed is composed of sand as well as glacial till, it is eroding, and "[n]o evidence exists that downcutting and lake bed lowering have a different ultimate effect on the erosion of the shore since the lowering allows the lake to move landward even if it is at almost an all-time low level." Pls.' Br. 30.

It may be true that lowering of any sort of the lake bed, be it composed of cohesive or sandy material, will as an initial matter erode the shoreline because of the steepened profile. See Tr. 106:18-107:1 (Meadows). However, defendant presented unrefuted evidence that lowering of a sandy shore allows for the possibility of mitigation by replacement in kind of the sand removed. Tr. 1296:4-9 (Nairn). Defendant's own

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the shoreline after 2005 that Ms. Ehret had not observed before. The court also notes Ms. Ehret's testimony that, for most of the 75 years that Ms. Ehret swam in Lake Michigan, "[t]he lake bottom was beautiful, silky white sand with ripple marks in it on a calm day," Tr. 754:15-17 (Ehret), and that, since 2005, "we've got all this junk," Tr. 754:18 (Ehret). However, as noted below in footnote 75, Part IV.E.1, the court cannot consider testimony from Ms. Ehret as expert testimony and thus must disregard her comments as to the technical composition of the material she found and the reasons that she found it there.

Similarly, neither the court nor plaintiffs' counsel can act as an expert and interpret darker and lighter patches appearing in an aerial photograph as either glacial till or sand. See Pls.' Br. 30 ("it looks like till" and "it can be seen under water") (citing PX 113 (1994 Site Visit Day 1) Fig. 14; PX Summary Tab 4 passim).

experts, however, provided evidence that lowering of a cohesive shore can have a very "different ultimate effect" because it is unclear whether mitigation is ever possible. Pls.' Br. 30. There no longer is a direct correlation between replacing material and effective mitigation because nourishment can act as an abrasive agent that exacerbates erosion, Tr. 1215:22-25 (Nairn); 176:15-178:14 (Chrzastowki), and the erosion of the lake bottom is considered permanent, Tr. 178:12-14 (Chrzastowki); PX 23 (1996 Report) 10; PX 24 (1997 Report) 8; PX 41 (1999 Report) 3. Parts IV.B.2 and V, below, address whether defendant provided the proper kind of material and the proper amount of material for effective mitigation at plaintiffs' properties.

Defendant acknowledges that the Corps considered the zone of plaintiffs' properties cohesive in its earlier Corps Reports, but it argues that this was an erroneous conclusion because that assumption was based on studies that did not focus on plaintiffs' zone. Def.'s Resp. 9. "Dr. Nairn testified that the scope of the area studied in the earlier [Corps] Reports did not in one instance include the plaintiffs' zone and, in another instance, only included a small stretch of the shoreline where the northern-most plaintiffs' properties are located." Def.'s Br. 23 (citing Tr. 1108:3-1111:11, 1342:1-11(Nairn)). Dr. Nairn stated during his testimony that the purpose of the 1996 Report and 1997 Report was to study the shoreline and the Corps' nourishment program, and that the 1996 Report studied the area from St. Joseph Harbor to 3.7 miles south, while the 1997 Report study area extended from St. Joseph Harbor to 5.6 miles south. Tr. 1109:24-1111:8 (Nairn). He then qualified the scope of the 1997 Report, stating that it "really relied [on] all the information collected on the first [1996 Report], so . . . going the extra three [miles] really weren't based on a lot of data." Id. at 1111:8-11 (Nairn).

Defendant's expert witness in geology, Dr. Larson, is the support for the conclusion in Dr. Nairn's expert opinion that the properties belonging to a majority of the plaintiffs are located on a sandy, not a cohesive, shoreline. See generally Tr. 972:16-1020:23 (Larson); Tr. 1213:20-1214:5 (Nairn) ("Dr. Larson provided the stratigraphy[36] and being a person with expertise in erosion processes, then I interpret that as to whether it's cohesive or is a sandy shore.") (footnote added). Dr. Larson found that the shoreline for some of the northern-most plaintiffs' properties "is a cohesive shore that then transitions to a sandy shore for the remaining larger group of plaintiffs' properties." Def.'s Br. 23 (citing DX 3 (Larson Report) 34; DX 28 (Glacial Geologic Map of Berrien County); DX 31 (Geologic Cross Section of Lake Bluffs North and South of St. Joseph); Tr. 1008:18-20 (Larson); Tr. 1212:21-1214:9, 1342:12-18 (Nairn)). In anticipation of this trial, Dr. Larson prepared a stratigraphy of the areas along the Lake Michigan shoreline encompassing plaintiffs' properties. Tr. 972:16-1020:23 (Larson). Dr. Larson testified

[36]"The stratigraphy means the layering of the sediments." Tr. 1003:9-10 (Larson).

that, in order to create the geologic map presented at trial, he drove through every path through the area and noted any exposure of geologic materials, such as sand and gravel. Id. at 981:4-9 (Larson) (citing DX 28 (Glacial Geologic Map of Berrien County)). He also testified that he used soil maps and published borings. Id. at 981:10-13 (Larson) (citing DX 28 (Glacial Geologic Map of Berrien County). Dr. Larson testified that he relied upon well logs that are on file with the Michigan geological survey in order to obtain information about the geology of the surface that lies below lake level. Id. at 1004:5-9 (Larson). He explained that well logs are the reports that well drillers must submit to the Michigan Department of Public Health, and that he uses the well logs in the same way that "petroleum people do:" he looks at the logs and tries to characterize the geology based on the information recorded in those logs. Id. at 1004:11-23 (Larson). Dr. Larson testified that he has used well logs extensively over the years for a variety of projects, and that he has found about 30% of them to be unreliable. Id. at 1006:7-11 (Larson). He testified that he deals with that variability by eliminating the logs that he finds unreliable, id. at 1006:19-20 (Larson), for example, logs containing obvious mistakes in the characterization of materials found and logs of uncertain location, id. at 1006:7-16 (Larson).

At trial, Dr. Larson reviewed the geological history of the area, describing the creation of Lake Michigan by a receding glacier that left behind a lake bed of alternating levels of till and sand, id. at 981:22-984:24 (Larson), and presented his stratigraphy of St. Joseph Harbor and the adjoining bluffs contained in DX 31, Tr. 1001:19-1003:16 (Larson). Dr. Larson explained that, south of the harbor, a layer of till exists above a layer of sand. Id. (citing DX 31 (Geologic Cross Section of Lake Bluffs North and South of St. Joseph)). Dr. Larson found that, south of the harbor in the direction of Grand Mere, "the till was no longer there[,] but it was mainly raw sand." Id. 1003:17-18 (Larson).

Plaintiffs attempted in cross examination, Tr. 1036:19-23 (Larson), and briefing to impeach Dr. Larson's testimony that the lake bed in plaintiffs' zone is a mixture of till and sand, see Pls.' Br. 29. In particular, plaintiffs point to a colloquy between Dr. Larson and plaintiffs' counsel during cross-examination where Dr. Larson acknowledged that he had "recognized downcutting" in an earlier study. Pls.' Br. 29; Tr. 1036:19-23, 1046:19-1049:2 (Larson) (citing PX 33 (1992 Pilot Study) 10). Dr. Larson testified that down-cutting "probably [did] not" indicate the presence of sand, Tr. 1037:2-4 (Larson). Rather, he considered down-cutting probably indicative of the presence of cohesive material. Tr. 1036:24-1037:18 (Larson).

As evidence that Dr. Larson's recent conclusions are erroneous, plaintiffs cite to

page 10 of the 1992 Pilot Study. Pls.' Br. 29 (citing PX 33(1992 Pilot Study) 10)).[37] That study concluded that "sand cover . . . is not sufficient to protect the till from erosion," located south of St. Joseph Harbor. PX 33 (1992 Pilot Study) 10. Dr. Larson did not agree with that statement at trial, Tr. 1047:23-1048:2 (Larson)[38], but Mr. Thompson, an employee of the Detroit District Corps from 1979 to 2003, id. at 397:17-19, stated that he agreed with the finding, id. 415:18-416:1 (Thompson). However, neither the colloquy with Mr. Larson nor with Mr. Thompson was focused on the lake bottom adjacent to plaintiffs' properties. Plaintiffs dismiss Dr. Larson's latest conclusions because his sources, the well-digger logs, are located "an average about 50 feet above the lake and up to 5000 feet inland from shore," as compared to "direct scientific recorded evidence by [the United States Geological Survey]" in the 1992 Pilot Study. Pls.' Br. 29 (citing Tr. 1046:6-18, 1071:1-24 (Larson)); DX 31 (Geologic Cross Section of Lake Bluffs North and South of St. Joseph).[39] Plaintiffs' effort to dismiss the results of Dr. Larson's stratigraphy because of the location "50 feet above the lake and up to 5000 feed inland," Pls.' Br. 29; Tr. 1046:6-18 (Larson) in misdirected. As Dr. Larson testified, "I used these well logs to see what was recorded below lake level under the bluffs, and then I characterized the geology based on standard geologic technique." Tr. 1005:17-20 (Larson) (emphasis added). This testimony makes clear that Dr. Larson employed actual subsurface measurements at the same depths as the lake bottom. His characterization of the lake bed is an extrapolation made from data on the same horizontal plane as the lake bed, not, as plaintiffs appear to suggest, from information at the surface.

Dr. Larson explained in testimony the reasons for his disagreement with the findings presented in the report contained in the 1992 Pilot Study. He explained that the authors of the report used two techniques: In the first technique, a sonar-like instrument scans only the surface of the lake bed and does not penetrate it. Tr. 1012:14-25 (Larson). This technique "doesn't [actually] tell you what's there," it simply "produces a picture of what the surface of the lake bed looks like," that is, it provides information on whether it

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[37]The 1992 Pilot Study examined an area that included plaintiffs' properties. See PX 33 (1992 Pilot Study) 23.

[38]In an immediately subsequent colloquy with plaintiffs' counsel concerning DX 28, Dr. Larson stated, "In fact, part of the shoreline has actually accreted over geological time, for example, right here where you [addressing Mr. Ehret, plaintiffs' counsel] live. We've added shoreline over the last 5,000 years." Tr. 1050:6-8 (Larson).

[39]Plaintiffs also argue that "Dr. Larson could have easily verified the source of the material washing up on the Grand Mere beaches by taking a ride in his 17 foot boat [using equipment] 'that allows [him] to look down into the water.'" Pls.' Br. 29, 30 (citing Tr. 871:12-19 (Larson)).

is "bumpy" or "flat." Id. Scientists therefore must interpret this information based on their understanding of how sediment should look, but "they really don't know" for sure. Id. at 1012:22-24 (Larson). The second technique uses radar to penetrate the ground and produce reflections that scientists must interpret. Id. at 1013:1-10 (Larson). Importantly, however, "they can't penetrate very far" using this technique because "the energy is consumed very rapidly." Id. at 1013:20-22 (Larson). Dr. Larson does not object to these techniques because he "think[s] it's good science." Id. at 1014:1 (Larson). His main objection is that this science should not stand alone; "it has to be verified." Id. at 1014:1-2 (Larson). "[N]ormally," he explains, "you . . . want to . . . . validate" with well logs. Id. at 1013:11-14 (Larson). The court found no discussion of well logs in the "Methods" section of the 1992 Pilot Study, PX 33 (1992 Pilot Study) 2-4, but "bottom sediment samples were collected," id. at 4. This "periodic sampling of the surface" contrasts with Dr. Larson's extensive use of well logs, which obtains samples of materials in strata that are at the same depth as the subsurface of the adjacent nearshore. Def.'s Resp. 10 (citing Tr. 1057:1-1058:17 (Larson)). Although Dr. Larson did not conduct the tests used in the 1992 Pilot Study, his well-logs represent a normal validation procedure that, in this case, invalidated the findings of the 1992 Pilot Study.[40]

Dr. Larson testified that his conclusions are consistent with what would be expected in the nearshore area of Lake Michigan, given its geological history.[41] See Tr. 1014:3-10 (Larson). The geological history indicates that "if you go way out into Lake Michigan," you should expect layers of till. Id. In the nearshore area, however, the geologic history indicates that "saucers of sand" are interspersed among the layers of till. Id. The conclusions of the 1992 Pilot Study that the entire area is till "makes no geological sense." Id. at 1014:3 (Larson). The 1992 Pilot Study appears to the court to be a results-oriented study – rather than a comprehensive overview of the processes influencing lakeshores – without discussion or apparent consideration of the geological history of Lake Michigan. See generally, PX 33 (1992 Pilot Study). Dr. Larson testified that the results of the 1992 Pilot Study are "preliminary." Tr. 1011:11 (Larson). The 1992 Pilot Study clearly states on the title page, "[T]his report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the [United States Geological Survey (USGS)]." PX 33 (1992 Pilot Study).

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[40]Dr. Larson also stated that the authors of the 1992 Pilot Study "were doing the mapping on a preconceived notion of everything being cohesive." Tr. 1013:18-20 (Larson).

[41]The court notes that the geological history is not disputed by plaintiffs. See Tr. passim; Pls.' Br. passim; Pls.' Resp. passim.

Plaintiffs' characterization of the evidence in the 1992 Pilot Study as "direct scientific evidence" of nearshore lake bed composition, Pls.' Br. 29, does not comport with expert testimony about the methods used in that study. Dr. Larson testified that the "side scan sonar" used to gather data is "an electronic signal that gives you an image." Tr. 1070:1-10 (Larson). The sonar, therefore, reflects an image of the location to be studied. See PX 33 (1992 Pilot Study) 31;[42] Tr. 1070:1-10 (Larson). Inexplicably, however, plaintiffs appear to tear down their own argument by eliciting from Dr. Larson testimony that the sonar images in the 1992 Pilot Study were on average about 1,500 feet offshore, see Tr. 1071:9-11 (Larson), which leaves 1,500 feet between the edge of the shore and the data from the 1992 Pilot Study unaccounted for. Plaintiffs' main argument is that Dr. Larson's stratigraphy is erroneous simply because it was not a sample from the actual study area. Pls.' Br. 29. While Dr. Larson acknowledged that "it would always be better to drill" in the study area, Tr. 1071:18-20 (Larson), plaintiffs point to no evidence that refutes the soundness of Dr. Larson's stratigraphic method.

Similarly, plaintiffs' argument that Dr. Larson's failure to look directly at the lake bottom from his boat constitutes a gap in Dr. Larson's methodology, Pls.' Br. 29, 30, is not corroborated by evidence. Dr. Meadows testified that "a commercially available underwater remote operative vehicle" known as Michigan's Remote Operated Vehicle for Education and Research (M-ROVER) was used "as a survey and sampling tool across the lakebed." Tr. 59:2-15 (Meadows). The 1996 Report further explained that M-ROVER "visually document[ed] glacial till exposure" by providing "photographs of the lakebed." PX 23 (1996 Report) 15. However, the 1996 Report studied the area from St. Joseph Harbor to 3.7 miles south, which does not include plaintiffs' zone. Tr. 1109:24-1111:8 (Nairn). The court has no indication that M-ROVER or any other means of photography was used to verify or refute Dr. Larson's findings in plaintiffs' zone specifically. See Pls.' Br. passim; Pls.' Resp. passim; Def.'s Br. passim; Def.'s Resp. passim. Furthermore, Dr. Larson explained as a scientific imperative that studies not rely solely on data from the surface of the lake bed to determine the composition of the underlying material. See Tr. 1013:1-14 (Larson) (discussing the need to validate studies based on results from the lake bed surface with well-logs that penetrate into the lake bed).

There is no dispute that, prior to this litigation, defendant consistently held the position that the shore in the area south of St. Joseph Harbor was cohesive. PX 33 (1992 Pilot Study) 10; PX 23 (1996 Report) 48; PX 24 (1997 Report) 1, 3-8. Mr. Thompson, a

[42]The page number in PX 33 has been completely cut off. The court notes that page 33 of PX 33 corresponds with page 434 of the alternate numbering system in that exhibit. See PX 33 (1992 Pilot Study) 33; Tr. 1069:22-23 (Larson).

fact witness who was not qualified as an expert, also reflected this view.[43] Dr. Chrzastowski, plaintiffs' expert who opined that the lake bottom was cohesive, based his evaluation on existing literature, aerial photography, historical maps, and ground photography, not his own personal tests. Tr. 206:20-207:12 (Chrzastowki). In fact, Dr. Chrzastowski has made it clear that he has "never reviewed the [Nairn Report]," Tr. 175:13-16 (Chrzastowki), and plaintiffs point the court to no evidence from Dr. Chrzastowski that he had reviewed Dr. Larson's testimony or the Larson Report, Pls.' Br. passim; Pls.' Resp. passim. Dr. Chrzastowski's opinion is based on the same documentary evidence that Dr. Larson credibly refuted. With no expert evidence from plaintiffs to counter defendant's expert's studies and explanations, and no expert review of Dr. Nairn's – and particularly Dr. Larson's – research conclusions regarding the lake bottom composition, the court finds that plaintiffs failed to prove by a preponderance of the credible evidence that plaintiffs' properties are located on a cohesive lake bottom.

Dr. Nairn described the shore along plaintiffs' zone as "predominantly sandy." Tr. 1216:10-14 (Nairn). The inference of this conclusion is that for any given plaintiff it is more likely than not that his or her property is located in a sandy zone. Dr. Nairn's testimony also acknowledges that the sandy zone may not fully extend to the northernmost of plaintiffs' properties. Id. at 1213:23-1214:5. The trial did not focus on particular properties. If, in further proceedings, some or all of a plaintiff's property is determined to lie in the northernmost zone characterized by Dr. Nairn and Dr. Larson in their expert reports as not predominantly sandy, the erosion damage to such property will be analyzed as damage to a cohesive shore. That analysis, unrefuted by defendant, Def.'s Br. passim; Def.'s Resp. passim, is that erosion of cohesive material is permanent and irreversible. Tr. 178:12-14 (Chrzastowki); PX 23 (1996 Report) 10; PX 24 (1997 Report) 8; PX 41 (1999 Report) 3.

2. Type of Nourishment

Plaintiffs argue, based on documentary admissions by defendant, that "[t]he beach nourishment material should have the same physical characteristics (composition, gradation, etc.) as the natural material found on the beach and nearshore." PX 41 (1999

[43]Plaintiffs' Exhibit 113 states that the lakeshore in Berrien Country is generally "covered with a blanket of glacial drift and unconsolidated lacustrian and aeolian sediments." PX 113 (1994 Site Visit Day 1) 2; Tr. 455:1-8 (Thompson); Pls.' Br. 28. Mr. Thompson testified that this is a document that he "probably would have authored much or most of. With input from other folks as well." Tr. 452:11-14 (Thompson). There is no indication on the face of the document or from Mr. Thompson that this guide represented anything more than a summary of existing research rather than an original study. See id.; PX 113 (1994 Site Visit).

Report) 4; Tr. 443:14-17 (Thompson);[44] Pls.' Br. 24-25. The mean size of the nearshore material south of the harbor is 0.233 mm and the size of the material north of the harbor is 0.210 mm. PX 93 (1973 Report) 10;[45] Pls.' Br. 24; PX 23 (1996 Report) 2 (stating that "fill material . . . from maintenance dredging" was approximately 0.2 mm); Tr. 1265:15-23 (Nairn).[46] Plaintiffs argue that "[o]ptimum fill material should have a median diameter of about 0.26 millimeter . . . ." PX 132 (1958 Study) 24; but see Tr. 572:4-9 (Selegean) (stating that he does not know whether he can agree with the optimum fill material recommended in the 1958 Study). The 1973 Report echoes the 1958 Study. PX 93 (1973 Report) 43a ("The material represented by the borings was found to be suitable as feeder beach material. A combination of the two borings has the same mean diameter (0.24 mm) as the required feeder beach material.").

In recent years, however, defendant has placed some "[c]oarse trucked material . . . on [the] feeder beaches." Pls.' Br. 23;[47] PX 24 (1997 Report) 5-6; Tr. 351:14-15 (Selegean) ("The coarse material was purchased from gravel pits and trucked to the site and placed by trucks."); see also DX 34 (St. Joseph Dredging) 2. The mean size of the

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[44]Mr. Thompson read this portion of PX 41 (Annual Report on the Section 111 Beach Nourishment Monitoring Program (1999 Report)) into evidence in the context of the effectiveness of the location of the feeder beach. Tr. 443:14-23 (Thompson).

[45]This section of PX 93 (Section 111 Detailed Project Report on Shore Damage at St. Joseph Harbor, Michigan (1973 Report)) was not specifically pointed out or discussed at trial. See Tr. passim.

[46]Dr. Nairn read this excerpt of PX 23 into the record, but he neither agreed nor disagreed with its contents. See Tr. 1265:15-23 (Nairn) (citing PX 23 (Geologic Effects on Behavior of Beach Fill and Shoreline Stability for Southeast Lake Michigan (1996 Report)) 2).

A later Corps document stated that the diameter of "[s]and obtained from the periodic maintenance dredging of the St. Joseph navigation channel" that is placed on the feeder beach is 0.02 mm in diameter. PX 113 (1994 Site Visit Day 1) 5. This evidence was not discussed at trial. See Tr. passim. The court assumes that this is a typographical error.

[47]Plaintiffs identify 1986 as the first year that trucked material was placed on the feeder beaches, Pls.' Br. 23, but the first date appearing in the records is 1976. PX 24 (Effectiveness of Beach Nourishment on Cohesive Shores, St. Joseph, Lake Michigan (1997 Report)) 6; DX 34 (St. Joseph Dredging) 2. The determinee reasons that the trucked material in 1976 is not relevant to this discussion because it was classified as "fine" material, rather than coarse, PX 23 (1996 Report) 5, and thus cannot be included with the trucked material that is coarse. See this Part IV.B.2.

trucked material is about 2.0 mm. PX 23 (1996 Report) 2, 5;[48] Pls.' Br. 24. In describing the material that is trucked in, a later Corps document stated, "This material is much coarser than the native beach sand, with a gradation that ranges from fine sand to gravel several inches in diameter." PX 113 (1994 Site Visit Day 1) 5; Pls.' Br. 25.[49] By adding the amount of material trucked throughout the years, plaintiffs calculate that, as of 1995, 376,096 cubic meters of the coarse material had been placed in the littoral zone by the Corps. Pls.' Br. 23; see PX 24 (1997 Report) 6.[50]

Although there is no testimony on this topic, plaintiffs argue persuasively from defendant's documentary admissions that the nourishment material brought in from other sources, usually by truck, and placed at the feeder beach is roughly ten times the diameter of the material dredged around St. Joseph Harbor. PX 24 (1997 Report) 5-6; Tr. 351:14-15 (Selegean); PX 93 (1973 Report) 10; PX 23 (1996 Report) 2, 5; Tr. 1265:15-23 (Nairn); PX 113 (1994 Site Visit Day 1) 5; Pls.' Br. 23-25. Defendant argues that "plaintiffs intimate that the placement of sediment larger in size than what the ambient characteristics of the beach invalidates the Corps nourishment program results." Def.'s Resp. 11. In making this argument, defendant does not refute that nourishment material brought in from outside of the littoral zone is significantly larger than the material dredged from the harbor.

Defendant attempts to distance itself from the conclusion in the 1999 Report that beach nourishment should "have the same physical characteristics" as the natural material on which it is placed. Defendant argues that the 1999 Report uses language that "reflects, at most, guidance (as opposed to mandatory compliance in order to achieve success) in the form of an opinion by the author." Id. at 12. Further, "the report cites no study to provide insight as to the legitimacy of the author's opinion." Id. Defendant argues that "sediment larger than the grain found on the beach will remain in place longer once it has settled," a "logical consequence" of Dr. Meadow's testimony that larger grain

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[48]These sections of PX 23 were not specifically pointed out or discussed at trial. See Tr. passim.

[49]This section of PX 113 was not specifically pointed out or discussed at trial. See Tr. passim.

[50]The court notes that, although it was not brought up in plaintiffs' briefing or discussed at trial, the Corps' 1996 Report has different figures for each year that nourishment was trucked in. Compare PX 24 (1997 Report) 6 with PX 23 (1996 Report) 5. This variation appears to have resulted from the haphazard records concerning dredging. See Tr. 623:4-626:15 (Selegean) (describing the four sources he used to compile DX 34, a record of dredging and placement at St. Joseph Harbor).

sediment is more difficult to move. Id. (citing Tr. 40:12-22 (Meadows)). "In fact, Dr. Meadows testified further that the sediment should be of a coarser grain size so that it would stay on the beach." Id. (citing Tr. 130:21-131:3 (Meadows)). However, the court finds, as discussed below, Dr. Meadow's testimony irrelevant to most of plaintiffs' properties.

The 1999 Report constitutes an admission and defendant points to no evidence that persuades or requires the court to find otherwise. The court deems defendant to have admitted the necessity for nourishment material to "have the same physical properties" as the natural material on the beach and nearshore. PX 41 (1999 Report) 4. The court notes that "should," PX 41 (1999 Report) 4, is "[u]sed to express obligation or duty," American Heritage Dictionary 1612 (4th ed. 2000), rather than, as defendant suggests, mere guidance or opinion. Def.'s Resp. 12.

The evidence presents various assessments of the efficacy of the material used at St. Joseph. See, e.g., PX 23 (1996 Report) 49 ("The analyses performed under this study suggest that the beach nourishment program at St. Joseph may provide at least partial protection to the underlying glacial till along and offshore of the feeder beach and the waterworks revetment section of shore. It is unclear whether the beach nourishment is having any negative or positive impact along the 3.5-km revetment section of shoreline south of the waterworks."), 48 ("Cross-shore modeling using COSMOS-2D indicates that, when compared to 0.2-mm sediment, the 2-mm sediment provides much superior protection to the underlying till in the inner surf zone and beach area (i.e., above a depth of about 1 to 2 m). The corollary to this finding is that the 2-mm sediment does not appear to provide superior protection to the section of the study shoreline where there is no beach, with the possible exception of protecting against local scouring in the immediate vicinity of the toe of the large revetments. Local scouring was predicted in the model tests with the 0.2-mm sediment."); PX 24 (1997 Report) 86 ("2-mm grain size sediment was no more effective than the 0.2-mm sediment in protecting the underlying till from exposure and downcutting . . . ."), 90 (recommending that nourishment comprise both fine and coarse grain components to be effective), 5 (One study "indicated that the fine sand has been a less-than-ideal material for nourishment, noting its short retention time and the fact that the fine sand does not fulfill the role of the coarse sediment which forms a large part of the natural beach closer to shore . . . ."). These studies were focused on locations, for example, in front of the "large revetments" that are not part of plaintiffs' properties and as to which the court has not examined evidence of the lake bottom. The studies are also written based on the presumption that the relevant lake bottom was cohesive, a presumption that this Opinion has rejected as to most of plaintiffs' properties in Part IV.B.1 above. In fact, plaintiffs' entire litigation position, premised on the Corps Reports and on plaintiffs' expert testimony, is that the lake bed in plaintiffs' zone is

cohesive, Pls.' Br. passim; Pls.' Resp. passim. Dr. Meadows' opinion that the nourishment program at St. Joseph could be better because "[i]t's recommended that the material not be what is simply convenient, but the material be of coarser grain size, something that will stay on the beach," Tr. 130:25-131:2 (Meadows); Def.'s Resp. 12, cannot be deployed to support defendant's arguments, Def.'s Resp. 12, in this context.

Plaintiffs argue persuasively, and with the support of the preponderance of the credible evidence, that the nourishment program needs to provide sediment that has "the same physical characteristics" as the shore that is to be nourished. Sediment that is on average ten times the size of the sediment interrupted at the piers does not appear to the court to have "the same physical characteristics." See PX 41 (1999 Report) 4. This portion of the nourishment program is, therefore, at best ineffective and will not be considered part of mitigation as to plaintiffs' properties abutting sandy lake bottoms.

C. Sediment Transport Rate

1. Net Littoral Drift Versus Gross Littoral Drift

"[O]ne would expect sediment transport under some storms [to move] towards the north and on other storms [to move] towards the south. The sum total of both of those transports is the gross transport." Tr. 40:1-4 (Meadows); see Tr. 694:10-14 (Selegean). Net sediment transport rate, or net littoral drift, is when "you add up the total rate of transport by one single point over a year's worth of balances, between northward and southward transport." Tr. 1139:19-1140:2 (Nairn).

Plaintiffs argue that the relevant littoral drift is gross littoral drift rather than net littoral drift because gross reflects "the total sand trapped" by the jetties. Pls.' Resp. 8. Plaintiffs argue that, while the net littoral drift represents the difference between the littoral drift moving north and the littoral drift moving south, it does not actually represent "all of the material that is being removed from the littoral system," whereas gross littoral drift does. Tr. 697:14-17, 700:6-24 (Selegean); Pls.' Resp. 9. In Plaintiffs' Memorandum, plaintiffs argue that "the piers capture or divert all sand from the north and south, not just the net difference of the two." Pls.' Mem. 12 (emphasis omitted). Plaintiffs suggest in briefing what they perceive as the significance of gross littoral drift: if the piers were removed, the entire two fillets (both north and south) would eventually move back south. Pls.' Resp. 8.[51] However, removal of the piers is not a type of relief

[51]Plaintiffs list figures from the 1997 Report pertaining to transport rate, but without explaining their significance. See, e.g., Pls.' Br. 5 ("Further on Page 17 [of PX 24 (1997 Report)], 'the southward directed transport component ranges from 375,328 m^3 (490,929 cy/yr)

at Line R8 (PX24-18 and 19) to 170,794 m^3/yr (223,398 cy/yr at R14.'") (citing PX 24 (1997 Report)). Dr. Nairn, the only witness to specifically discuss these figures, testified only that the 84,000 cubic meters in the 1997 Report was an assumption that he did not make in his expert report. Tr. 1282:18-1285:15 (Nairn). In a different section of its briefing ("Effectiveness of Beach Nourishment Program"), plaintiffs also highlight Dr. Meadows' calculations based on the same section of the 1997 Report cited on page 5 of Plaintiffs' Brief. Compare Pls.' Br. 12-13 with Pls.' Br. 5-6. Dr. Meadows calculated that "the amount [of sediment] trapped by the piers," that is, the amount "taken out of the littoral system," is approximately 681,000 cubic yards per year, arrived at by adding the south and north transport amounts located at a profile near the jetties. Tr. 161:11-162:15 (Meadows) (citing PX 24 (1997 Report) 18)); Pls.' Br. 12-13. Plaintiffs' counsel attempted to establish that the "average annual longshore sediment transport" would be the same at the jetties and at the profile where these measurements were taken. See Tr. 238:16-20 (Chrzastowski); see also Pls.' Br. 6 ("One would expect similar values for profiles located north of the harbor. [The profile where the measurements were taken] is just south of the jetties."). There appears to have been a misunderstanding between plaintiffs' counsel and plaintiffs' expert witness:

> Q: And would you expect the littoral drift, the average annual longshore sediment transport to be any different at the jetties than at Profile 8 if the jetties were not ever built?
> A: I just want to make sure I understand the question. So what we're doing is imagining a hypothetical situation that there are no jetties and then considering how the profile change would be at R-8?
> Q: Yes – no, whether the littoral drift at the jetties would be similar to the littoral drift that shows for Profile R-8?
> A: No. Without the jetties . . . the net transport at R-8 would be southward.
>
> . . . .
>
> Q: Okay. If the jetties had never been built, would all the sand to the north and south of the piers be moving to the south, then?
> A: That is correct.

Tr. 238:16-239:24 (Chrzastowski). Because of what the court perceives to be a misunderstanding, plaintiffs provided testimony stating nothing more than that "all the sand to the north and south of the piers" would be moving south if the jetties had never been built. Tr. 239:21-24 (Chrzastowski). This neither supports nor refutes the suggestion in plaintiffs' briefing that the gross littoral drift at Profile 8 is identical to the gross littoral drift at the jetties. Plaintiffs nevertheless assert that 681,000 cubic yards is the annual gross littoral drift that the Corps should be replacing. Pls.' Resp. 4; see Tr. 163:18-25 (Meadows); Pls.' Br. 5-6, 12-13.

At the request of plaintiffs' counsel during cross-examination, Dr. Selegean performed

available in the proceeding.

In their Memorandum, plaintiffs stated that "[t]he gross total amount is equal by the Corps numbers to 110,000 divided by .3 (for 30% interruption) to 366,666 cubic yards per year[,] plus river sand. . . . This is the total amount of material taken annually from the downdrift properties, public and private." Pls.' Mem. 12. One hundred and ten thousand cubic yards had been considered by the Corps, prior to this litigation, as the amount of net southerly littoral drift blocked by the piers, PX 93 (1973 Report) 59; PX 32 (Interim Report 1975-1984) 5; Tr. 420:17-20 (Thompson) (stating that he considered

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the same calculation made by Dr. Meadows and arrived at roughly the same results. Tr. 695:14-16 (Selegean). In the same cross-examination, Dr. Selegean also performed a similar calculation using slightly different inputs from page 25 (the potential alongshore transport for 1992 calculated in 1964) of the 1997 Report and arrived at 755,217, Tr. 696:15-17 (Selegean), although he was not clear as to the units of measurement, Tr. 694:1-6 (Selegean). Dr. Selegean agreed that if the piers were 100% effective at trapping sediment and if these calculations are "actually a correct gross number," then the calculations would represent "all the material that was removed from the littoral system." Id. at 700:15-24 (Selegean). Nevertheless, Dr. Selegean did not agree that the calculations he performed at the request of plaintiffs' counsel represented the correct gross numbers, nor did he ever testify to any relationship between the calculations and any sediment budget. See id. at 692:10-700:24 (Selegean). As the transcript makes clear, Dr. Selegean was coached or prompted through these calculations by plaintiffs' counsel, never testified as to their accuracy, and did not explain the relevance of knowing "all the material that was removed from the littoral system." See id.

Further to their discussion of littoral drift, plaintiffs list more figures: The Corps' 1999 Report identifies the "Cumulative Shortfall" as of January, 2000, to be 327,000 cubic yards of sediment. PX 41 (1999 Report) 4; Tr. 711:15-18 (Schweiger); Pls.' Br. 4. Plaintiffs also point out that the 1999 Report states that the Authorized Average Quantity" is 110,000 cubic yards. PX 41 (1999 Report) 4; Pls.' Br. 4. Plaintiffs do not explain the significance of these figures to the issue of gross littoral drift. See Pls.' Br. 4. Mr. Schweiger, an employee of the Corps, testified that he knew of the 327,000 cubic yards of shortfall at the time of the 1999 Report. Tr. 711:15-21 (Schweiger). Plaintiffs' counsel then asked Mr. Schweiger whether he understood "the provision in the nourishment program . . . of replacement of net littoral drift [to] be the same as replacing all material removed from the littoral system," Tr. 712:14-17 (Schweiger), a question the witness did not appear to understand and ultimately never answered. See Tr. 712:24-717:21 (Schweiger). Without clarifying testimony and documentary evidence from plaintiffs, the court cannot reach any conclusions about those subjects.

Plaintiffs also cite to PX 2, Pls.' Br. 5, an exhibit that was not admitted into evidence, let alone specifically pointed out or discussed with a witness. See Tr. passim. The court will not consider PX 2 as evidence and disregards arguments based on PX 2.

110,000 cubic yards the figure to be followed at the time of the Interim Report 1975-1984); PX 22 (1974 Report) 235; PX 23 (1996 Report) 2; PX 24 (1997 Report) 17; PX 41 (1999 Report) 4. According to the 1973 Report, "[t]otal nearshore erosion attributable to the Federal navigation project is about 96,000 cubic yards per year. Total nearshore erosion is 316,000 cubic yards per year. Thus erosion attributable to the navigation project is only 30 percent of erosion due to all causes." PX 93 (1973 Report) 32; see also PX 22 (1974 Report) 235 ("[Thirty] percent of the total annual erosion of 368,000 c.y. attributed to all causes has been calculated to be 110,400 cubic yards. This figure, then, represents the total loss of material to the south area because of interruption of the littoral drift by the Federal navigation structures. This amount of material is to be replaced yearly."); PX 41 (1999 Report) 4; Tr. 63:5-12 (Meadows) (testifying that, according to the 1973 Report, 30% of the total loss of sediment was 110,000 cubic yards per year) (citing PX 93 (1973 Report) 59); Tr. 655:16-21 (Selegean) ("[Thirty] percent of that total erosion the author claims [316,000 cubic yards per year] is due to the harbor.") (citing PX 93 (1973 Report) 32). If the court assumes, as the Corps appears to have done in 1973, that littoral drift directly correlates to erosion, see PX 93 (1973 Report), the 366,666 cubic yards would represent the total net southerly littoral drift rather than the "gross total amount," as asserted by plaintiffs. See Pls.' Mem. 12; see also PX 93 (1973 Report). The court disregards calculations and testimony in briefing from plaintiffs' counsel without a basis in witness testimony. See Part III.C.

Plaintiffs have no testimony in the record endorsing the use of gross littoral drift in calculating a sediment budget and produced no report that actually uses gross littoral drift in calculating the necessary nourishment rate. Tr. passim. Plaintiffs' own experts utilized net littoral drift in calculating the damage caused by the jetties. See, e.g., Tr. 37:2-11 (Meadows). Plaintiffs' scant support includes a definition of gross littoral drift from its expert, see, e.g., Tr. 39:16-40:8 (Meadows), repeated by defendant's Rule 30(b)(6) witness, Tr. 697:14-17, 700:20-24 (Selegean), and an identification of what that gross littoral drift might be: Dr. Meadows testified that to determine the total amount of sand removed from the littoral system, one must add the material accumulating at the north and south fillets with "whatever has been lost to the offshore region," Tr. 46:18-47:2, 44:4-45:1 (Meadows), and performed such a calculation, without, however, the unknown number lost to the offshore region, 161:11-162:15 (Meadows) (citing PX 24 (1997 Report) 18)); Pls.' Br. 12-13. However, even though he was plaintiffs' own expert, Dr. Meadows never explained the significance of this figure in relation to the sediment budget. See Tr. 46:18-48:15 (Meadows). None of the testimony adduced by plaintiffs on this subject can be construed as an endorsement of gross littoral drift as an element in the calculation of loss of sediment.

The witnesses who commented on the possible use of gross littoral drift vis-a-vis net littoral drift in the calculations for this case explicitly stated that gross littoral drift was not applicable in a sediment budget, Tr. 1141:1-13 (Nairn); Def.'s Resp. 8 n.3, did not feel competent in discussing the distinction, Tr. 712:14-714:25 (Schweiger), or simply did not understand how gross littoral drift could fit into the equation, Tr. 437:6-19 (Thompson);[52] see Tr. 692:3-21 (Selegean). The very cornerstone of plaintiffs' argument, the 1973 Report, states that the amount of beach nourishment necessary to mitigate the erosive effect of the harbor is based on the net littoral drift. PX 93 (1973 Report) 59; see also PX 32 (Interim Report 1975-1984) 5. Every subsequent report, whether it is marshaled to support plaintiffs' case or defendant's case, uses net littoral transport. See, e.g., PX 22 (1974 Report) 235; PX 23 (1996 Report) 2; PX 24 (1997 Report) 17; PX 41 (1999 Report) 4; DX 1 (Nairn Report) 3-63 to -65. In the total absence of expert explication of the relevance of gross littoral drift to the evidence in the case, the court adopts the approach accepted by all of the witnesses who testified on the subject and all of the reports in this litigation and focuses on net littoral drift. See also Def.'s Resp. 8 n.3.

2. Net Southerly Littoral Drift

Although plaintiffs do not consider net littoral drift directly relevant to this discussion, see Pls.' Resp. 9, the data they use to derive their figure for gross littoral drift comes from the Corps Reports where the Corps admitted that 110,000 cubic yards per year represented the interruption of the net southerly transport rate. See Tr. 161:11-162:15 (Meadows); PX 24 (1997 Report) 18); Pls.' Br. 12-13. Plaintiffs correctly point out that defendant accepted 110,000 cubic yards per year as the net littoral drift until the time of this litigation. Pls.' Mem. 1.

The court now weighs the evidence concerning the quantity of net southerly littoral drift blocked by the jetties in order to determine how much material needs to be replaced in sandy portions of the littoral zone. Plaintiffs appear to argue that the net littoral drift to the south is at least 110,000 cubic yards per year, as shown in the 1973 Report, if not

[52]Plaintiffs attempted to elicit an endorsement of using gross littoral transport from Mr. Thompson by asking whether "the correct way, according to [the 1999 Report], would be to consider both" the removal of material from the North and South side of the jetty, to which Mr. Thompson agreed. Tr. 438:16-18 (Thompson). However, this question is ambiguous since both net littoral drift and gross littoral drift consider littoral drift in both directions; the former by taking the difference between northerly and southerly drift, and the latter by adding the two together. In the context of the rest of his testimony, Mr. Thompson cannot be said to endorse the use of gross littoral drift. See id. at 437:6-487:1 (Thompson).

more. See Pls.' Br. 12-13, 24; Pls.' Mem. 1. Defendant argues that the figure is approximately equal to 50,000 cubic yards per year, as shown in the Nairn Report. Def.'s Br. 13-14. The court considers evidence that could affect these calculations, and then it examines the bases for each parties' position.

a. Sediment Passing Through Permeable Piers

Defendant states in its post-trial briefing that "plaintiffs seem to suggest – without providing any specific cause and effect or quantifying (if they were correct) – that Dr. Nairn's sediment budget is incorrect because they believe that the jetties were permeable to the passage of sediment." Def.'s Br. 24. The court's interpretation of plaintiffs' briefing is that plaintiffs are asserting more than just that Dr. Nairn's sediment budget is incorrect. Rather, plaintiffs argue that the piers at St. Joseph Harbor were not completely impermeable to sediment prior to their encasement in steel, and the unaccounted-for sediment passing through the piers results in a higher rate of sediment transport than was previously calculated, even in the 1973 Report. See Pls.' Br. 6-11.

Plaintiffs acknowledge that the piers were intended to be impermeable and include reference to evidence on the subject in their briefing. Pls.' Br. 6. Dr. Chrzastowki testified that, "[a]ssuming appropriate maintenance and upkeep," the purpose of a rock-filled timber crib would be as a total barrier to sediment. Tr. 202:25-203:2 (Chrzastowki). The Corps' 1958 "Berrien County, Michigan, Beach Erosion Control Study" (1958 Study) stated that the original structure "constructed in 1836 . . . . consisted of an impermeable wooden crib." PX 132 (1958 Study) 18; Tr. 647:10-12 (Selegean); Pls.' Br. 6.

However, "as it would deteriorate, [a rock-filed timber crib] would have voids in it and there could be an opportunity for some sand getting through those rock-filled timber crib." Tr. 202:22-24 (Chrzastowki). An 1865 Map of St. Joseph's Harbor (1865 Map) indicated that St. Joseph Harbor was not always appropriately maintained because it pointed out that different sections of the jetties were in various stages of decay. PX 136 (1865 Map of St. Joseph's Harbor (1865 Map)); Tr. 681:24-682:3 (Selegean); Pls.' Br. 7. Plates from the 1973 Report also show that the harbor had undergone various repairs prior to 1950, indicating that the jetties at certain points needed upkeep. PX 93 (1973 Report) Plates 3-5; Pls.' Br. 7.[53] Plaintiffs point to testimony from Mr. Richard Albert Voss, who testified that when he swam under, although not through, the piers, Tr. 788:22-25 (Voss),

[53]The plates in the 1973 Report were not specifically pointed out or discussed at trial, but a plate apparently very similar or identical to those found in the 1973 Report was discussed by Mr. Thompson. Tr. 463:18-467:5 (Thompson); PX 113 (1994 Site Visit Day 1) Fig. 9.

between the years 1946 to 1956, he observed that "every so many feet, maybe 15 feet, was about a 3-by-3 hole that went into the water of Lake Michigan." Tr. 789:16-18, 790:1 (Voss); Pls.' Br. 10. Although the holes were covered, "when the waves came in the water would gush up through this hole in recovering, further indicating that it was open underneath." Tr. 789:19-21 (Voss); Pls.' Br. 10.[54]

A "Coastal Engineering Technical Note" from the Corps in 1992 (1992 Note) states that "[r]ubble-mound coastal structures contain voids between individual armor units. These voids . . . may result in the passage of water and sediment. The volume of sediment passing through breakwaters, jetties, and groins can be substantial . . . ." PX 114 (1992 Note) 1; Tr. 467:14-21 (Thompson); see Pls.' Br. 10. Thus, plaintiffs suggest that the encasement of St. Joseph Harbor jetties in steel was for the purpose of sealing them such that sand would no longer pass through. Pls.' Br. 10 (citing PX 114 (1992 Note) 1-8; Tr. 467:10-468:25, 468:4-9 (Thompson)). Mr. Thompson testified that he had no personal knowledge as to why the timber cribs at St. Joseph were encased in steel, Tr. 484:3-6 (Thompson), but he also stated that harbor structures, including St. Joseph Harbor, tended to be encased in steel "as the timber rock crib deteriorated over time," Tr. 463:24-464:3 (Thompson). He also testified that there were differences between the timber cribs of St. Joseph Harbor prior to their encasement in steel and the rubble-mound structures referred to in the 1992 Note. Tr. 481:6-8, 483:10-15 (Thompson) ("At least as initially constructed, a timber crib would be fairly impervious . . . . Whereas, a rubble structure has large and varied voids."). However, as a timber crib started to deteriorate, "[i]t would begin to approach a rubble structure." Tr. 483:16-19 (Thompson).

Plaintiffs argue that "the piers were not trapping large quantities until the steel encasement was completed." Pls.' Br. 29 (emphasis omitted).[55] The court understands

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[54]Plaintiffs also present, as evidence of the decay of the wooden cribs, photographs showing the destruction of a wooden seawall built to protect some of plaintiffs' property. PX Summary Tab 1, 29; Tr. 752:9-15 (Ehret); Pls.' Br. 10. Presumably, by placing this reference in the section entitled "The Piers (Im) Permeable," plaintiffs are suggesting a generalized assessment as to the susceptibility of wooden structures to the elements. See Pls.' Br. 10.

[55]In support of this assertion, plaintiffs quote from the United States Geological Survey: "The harbor jetties to the north of this area have effectively trapped some of the southerly littoral drift . . . ." PX 33 (1992 Pilot Study) 10; Tr. 415:18-416:1 (Thompson); Pls.' Br. 28. Plaintiffs assert that "[t]he use of the word 'some' . . . adds to the weight of the idea that the piers were not trapping large quantities until the steel encasement was completed." Pls.' Br. 28-29 (emphasis omitted). This quote may be consistent with plaintiffs' view of the so-called peremability of the jetties prior to steel encasement, but it does not offer definitive support for their conclusion. The littoral drift that was not trapped by the jetties might have been lost beyond the depth of closure,

the import of the argument to be that the Corps' net littoral drift calculation (prior to this litigation) of 110,000 cubic yards per year does not fully and accurately represent the total net sediment transport rate because the 110,000 cubic yards figure is based on the material trapped against the northern jetty prior to the encasement of the jetties in steel, Tr. 1302:14-23 (Nairn) (testifying that 110,000 cubic yards was partly derived from surveys done in 1907 and 1954); see also PX 32 (Interim Report 1975-1984) 5 (stating that "[t]he [1973 Report] determined the net littoral transport interrupted by the harbor structure to be 110,000 cubic yards per year based on available topographic and hydrographic data for the period 1907 to 1971), Tr. 644:24-645:5 (Selegean) (testifying that the jetties were encased in steel from approximately 1952 to 1988 or 1989). If some material was still passing through the jetties at the time of the calculation, the interrupted net littoral drift after total steel encasement could be more than the 110,000 cubic yards per year calculated in the 1973 Report. Thus, plaintiffs argue, "[t]he best explanation for the contradictory information about net littoral drift is that the CORPS felt that only 30% of the sand was being blocked because of the decayed condition of the piers and that 110,000 cy/yr would make up for it." Pls.' Br. 31-32.[56]

However, plaintiffs have failed to prove that the piers were ever permeable. All of the evidence that plaintiffs present is inconclusive. Plaintiffs implicitly interpreted the 1997 Report's statement that "the harbor jetties due to their sheet-pile construction, were assumed to be complete barriers to alongshore transport," PX 24 (1997 Report) 27, as a negative inference that – without the sheet-piling – the jetties would not be complete barriers to transport, see Pls.' Br. 9. This is demonstrated in the following colloquy between plaintiffs' counsel and Dr. Selegean concerning data from the 1997 Report:

> Q: Do you agree that sheet pile construction causes the jetties to be complete barriers?

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among other possibilities.

[56]Plaintiffs point to Mr. Thompson's testimony regarding a panel answer at a Shoreham meeting stating that "[t]here is really no way of knowing" whether 110,000 cubic yards per year is equal to 30% of the erosion, PX 61 (Memorandum for Record: Shoreham, MI Village council Meeting 1994) 1; Tr. 448:2-3 (Thompson); Pls.' 10. The court understands plaintiffs' use of Mr. Thompson's testimony as support for what plaintiffs perceive to be "the contradictory information about net littoral drift." Pls.' Br. 31. This argument, the court finds, is very unhelpful to plaintiffs because plaintiffs' evidence offers no alternative quantitative analysis of the relationship between the jetties and erosion, an admission in the 1973 Report on which plaintiffs' entire liability case depends.

A: I believe there are complete barriers prior to sheet metal going in, complete barriers in the sense that sand was not – at least not an appreciable quantity of sand, was able to pass through a structure . . . ."

Tr. 588:20-25 (Selegean). Although plaintiffs' interpretation is consistent with a negative inference drawn from the 1997 Report, a statement asserting that a certain kind of construction is impermeable does not automatically support the idea that a different kind of construction is not impermeable. Similarly inconclusive is Mr. Voss's eye-witness testimonial evidence showing that some water may have been able to pass through the north jetty as late as 1956. Tr. 789:19-21 (Voss); Pls.' Br. 10. Mr. Thompson testified that just because a wave can get through the jetties, one cannot assume that sediment will get through as well. Tr. 458:16-23 (Thompson). In fact, he testified that it "would be fairly difficult" for sand to get through a rock-filled timber crib. Id.

There is, on the other hand, a preponderance of the credible evidence that the jetties are, and long have been, impermeable. As defendant correctly points out, plaintiffs' own expert witness testified that the piers were impermeable even prior to their encasement in steel. See, e.g., Tr. 202:25-203:2 (Chrzastowski) (testifying that the purpose of a rock-filled timber crib, assuming appropriate maintenance and upkeep, would be to act as a total littoral barrier); Tr. 49:8 (Meadows) (testifying that the piers are currently a "near total littoral barrier"); PX 132 (1958 Study) 18 ("This pier [that was constructed in 1836] consisted of an impermeable wooden crib . . . ."); PX 24 (1997 Report) 79 ("The bypassing analysis showed that the combination of the long jetties and the deep navigation channel acts as a total littoral barrier, trapping all sediment reaching this area from either the north or the south.").

Plaintiffs simply present no evidence, testimonial or documentary, to corroborate their assertion that the alleged permeability of the piers means that 110,000 cubic yards per year represents only 30% of the sediment blocked by the piers. Pls.' Br. 31-32. To the contrary, the 1973 Report and many witnesses interpreting these figures assert that the Corps' position up until the time of litigation was that 110,000 cubic yards represents 100% of the sediment blocked by the piers. See PX 93 (1973 Report) 59; PX 32 (Interim Report 1975-1984) 5; Tr. 420:17-20 (Thompson) (stating that he considered 110,000 cubic yards the figure to be followed at the time of the Interim Report 1975-1984); PX 22 (1974 Report) 235; PX 23 (1996 Report) 2; PX 24 (1997 Report) 17; PX 41 (1999 Report) 4. In at least two of these same Corp Reports, the Corps took responsibility for causing 30% of the erosion south of the structures. PX 93 (1973 Report) 32; PX 22 (1974

Report) 235.[57] At one point, plaintiffs acknowledge that the Corps viewed 110,000 cubic yards per year as the total amount of sediment blocked by the piers: "Until this litigation, the Army Corps had repeatedly endorsed the fact that the structures at St. Joseph had interrupted, dredged or diverted 110,000 cubic yards per year of sand over the years and that amount was considered to be 30% of the total annual loss to the littoral zone." Pls.' Br. 30-31. The only differing testimony does not support plaintiffs' position, but rather indicates confusion as to what relation the 30% in the 1973 Report had with 110,000 cubic yards. See Tr. 447:13-450:22 (Thompson); Pls.' Br. 10.[58] The court cannot rely on "testimony" of one of the parties introduced by counsel in briefing, see Part III.C supra, that "only 30% of the sand was being blocked because of the decayed condition of the piers and that 110,000 cy/yr would make up for it," Pls.' Br. 31-32. The Corps maintained, up until the time of this litigation, without contradiction and as an admission, that the piers caused approximately 30% of the erosion to the south of the harbor by blocking approximately 110,000 cubic yards of sediment from the littoral zone per year.

b. Sediment from St. Joseph River Blocked by Dams

In their pre-trial briefing, plaintiffs argue that the Nairn Report "ignores the river sand which is the major source of sand for the beaches," Pls.' Mem. 1, arguing that "the flow of sand would be even greater than 90,000 cy/yr experienced for dredging by the Corps." Id.. Plaintiffs allege that "millions of cubic yards have been trapped behind dams which are in the absolute control of the federal government Federal Energy Regulatory Commission (FERC)." Id. at 9. However, as defendant correctly points out, "Dr. Nairn's sediment budget takes into account the fact that dams on the St. Joseph River do block some amount of river sand from the littoral system." Def.'s Resp. 8; Tr. 1120:6-1121:17; DX 25 (Long-Term Sediment Budget Downdrift of St. Joseph Harbor

[57]When two witnesses, Dr. Meadows and Dr. Selegean, testified that "30%" represents a percentage of the total loss of sediment, it appears that they are referring to total cubic yards lost to the littoral system, including 110,000 cubic yards lost by interruption of littoral drift. See Tr. 63:5-12 (Meadows) (testifying that, according to the 1973 Report, 30% of the total loss of sediment was 110,000 cubic yards per year) (citing PX 93 (1973 Report) 59); Tr. 655:20-21 (Selegean) ("[Thirty] percent of that total erosion the author claims [316,000 cubic yards per year] is due to the harbor.") (citing PX 93 (1973 Report) 32).

[58]Specifically, Mr. Thompson testified that, in his estimation, the 30% and 110,000 are not the same thing, Tr. 447:13-14 (Thompson), but he was unable to explain to the court his view of the relation between those two figures, see Tr. 450:1-10 (Thompson). The court takes Mr. Thompson at his word and accepts his professed uncertainty, based on the fact that "[he] can't speak for the time and the folks" who were discussing the correlation between these figures. See 450:5-6 (Thompson).

(Sand Only)) column xv (showing amount of sand trapped due to dams). Plaintiffs did not impeach or even address this calculation at trial. See Tr. passim.

Plaintiffs point to testimony from Mr. Jay Kevin Wesley, a fisheries manager for the Michigan Department of Natural Resources, Fisheries Division. Tr. 897:17-20 (Wesley); Pls.' Br. 27. Mr. Wesley has a bachelor's degree in fisheries biology and a master's degree in natural resource management. Tr. 898:2-4 (Wesley); Pls.' Br. 27. By consulting a 1999 State of Michigan Department of Natural Resources study titled "St. Joseph River Assessment" (1999 River Assessment) that Mr. Wesley co-authored, Tr. 898:24 (Wesley), the witness described the path of the St. Joseph River, which starts 210 miles upstream from Lake Michigan, Tr. 899:17-18 (Wesley), and makes its way to Lake Michigan, discharging 4,598 cubic feet of water per second at the mouth of the river, Tr. 901:19-902:24 (Wesley); PX 90 (St. Joseph River Assessment (1999 River Assessment)) 26, 119; Pls.' Br. 27. Plaintiffs emphasize Mr. Wesley's testimony that "[m]ost of the St. Joe River proper flows through old channels that were formed by old glacial river systems and flows through what's called glacial outwash material which is typically sandy material." Tr. 900:22-25 (Wesley); Pls.' Br. 27. The court understands plaintiffs to be arguing that the St. Joseph River picks up sandy material in its path and dumps it in the St. Joseph Harbor. See Pls.' Br. 26-27; Pls.' Mem. 1 (alleging that "the river sand . . . is the major source of sand for beaches"). Notably, plaintiffs do not specifically point to evidence even from Mr. Wesley that the St. Joseph River carries sediment to Lake Michigan via the St. Joseph Harbor. See Pls.' Br. 27-28. The fact of this process is not in dispute, Tr. 628:17-18 (Selegean); Tr. 915:14-20 (Wesley), but plaintiffs do not carry their burden of showing an alternative, larger amount of sand in the sediment budget from St. Joseph River than the amount credibly calculated in the Nairn Report. See Pls.' Mem. 1.

c. Possible Loss of Sediment into Deep Water

Plaintiffs also ask in briefing whether the jetties "direct the river sand out of the littoral zone." Pls.' Br. iv. Plaintiffs argue with what they perceive to be "defendant's self-serving assumption . . . that diverted sand (or at least substantial amounts thereof) are captured in the 24-foot deep flare at the mouth of the piers. Defendant believes the flare acts as a perfect settling basin or catch basin or sink." Pls.' Resp. 5.

The court examines whether Dr. Nairn takes into account possible losses of sediment from the littoral zone: from river sediment that jets out into deep water or longshore transport sediment that is diverted by the jetties into deep water. The court notes that, in analyzing diagrams of the lake bed changes and nearshore currents, Dr. Nairn testified that "there's no growth in zone 3 [the zone furthest from the shore] related

to offshore diversion . . . either due to the coastal current or the river currents." Tr. 1171:8-11 (Nairn) (citing DX 15 (Lakebed Change Between 1907 and 1954); DX 17 (Nearshore Currents (NW Storm) with High River Flow on 1907-1954 Lakebed Change (HYDROSED))).[59] It is clear that Dr. Nairn considered the issue and concluded that no significant sediment is lost into deep water because of the jetties.

Defendant is correct in stating that "[p]laintiffs . . . do not cite any evidence to support their inference that the jetties 'direct the river sand out of the littoral system.'" Def.'s Resp. 9 (citing Pls.' Br. iv).

i. River Sediment Jetting into Deep Water

Contrary to plaintiffs' argument, there is substantial evidence to indicate that much of the river sediment carried downstream is deposited in the harbor and accounted for by dredging. Dr. Nairn testified that "[w]e found that there's no significant amount of sand being jetted into deep water based on the river processes. In fact, it joins the littoral stream and then eventually makes its way back into the shoreline." Tr. 1173:24-11742 (Nairn) (citing DX 19 (Sedimentation Due to an Extreme (20-year return period) Flow Discharge with 1991 channel Bathymetry)).[60] Mr. Wesley testified that, although there are means of measuring sediment movement in a river, he is not aware of any specific studies to measure this at the St. Joseph River. Tr. 915:25-916:8 (Wesley). He testified also that he was aware that the Corps tests samples of sediment carried by the St. Joseph River and then dredged from the inner St. Joseph Harbor to determine whether that material is suitable for beach nourishment. Id. at 914:23-915:6 (Wesley). Plaintiffs acknowledge that "there has always been substantial river sand to be dredged." Pls.' Mem. 10. Dr. Selegean discusses how "river material is being carried downstream and deposited somewhere in the channel there." Tr. 628:17-18 (Selegean). The implication of this testimony is that, even without data as to the specific amount of material in the littoral system that originates from the St. Joseph River, that material is accounted for

[59]Copies of DX 15 and DX 17 are also found on pages 3-54 and 3-56 of the Assessment of the Causes of Erosion in the Vicinity of St. Joseph Harbor, Michigan (Nairn Report). Tr. 1169:1-3 (Nairn); compare DX 1 (Nairn Report) 3-54, 3-56, with DX 15 (Lakebed Change Between 1907 and 1954) and DX 17 (Nearshore Currents (NW Storm) with High River Flow on 1907-1954 Lakebed Change (HYDROSED)).

[60]A copy of DX 19 is also found on page 3-57 of the Nairn Report. Tr. 1172:6-8 (Nairn); compare DX 1 (Nairn Report) 3-57, with DX 19 (Sedimentation Due to an Extreme (20-year return period) Flow Discharge with 1991 channel Bathymetry).

because it is included in the dredging of the harbor. See id. The 1973 Report states as much:

> For the last 12 years the average annual dredging at St. Joseph Harbor has been about 90,000 cubic yards. Of this, about 40,000 cubic yards has been from the entrance channel and would be attributable to littoral drift. The remainder would be attributed to sediments deposited by the St. Joseph River and is dredged up-stream of the harbor entrance.

PX 93 (1973 Report) 11. Dr. Nairn's sediment budget has several columns addressing river sand, including "Total sand supplied by the river" and "River sand reaching the lake." DX 25 (Long-Term Sediment Budget Downdrift of St. Joseph Harbor (Sand Only)) columns iii, iv. Dr. Nairn testified that his sediment budget accounted "for the sand that was trapped in the inner harbor, dredged, and then lost through upland disposal." Tr. 1185:20-23 (Nairn).

If there is river sand diverted into deep water and lost to the littoral zone, plaintiffs point to no evidence indicating how much sediment is lost or even that this loss would be substantial. See Pls.' Br. passim; Pls.' Resp. passim; Pls.' Mem. passim. The 1973 Report states, "It is considered that the grain size of the sediments brought down by the rivers would generally be too fine to substantially contribute to the littoral drift pattern." PX 93 (1973 Report) 11. This testimony indicates that the sand from the river that is allegedly lost beyond the depth of closure would not have a substantial effect on the sediment budget. Consistent with this conclusion is Dr. Chrzastowski's testimony that the shoreline at St. Joseph is a "wave dominated coast, not a river dominated coast." Tr. 171:18 (Chrzastowski). This means that the river is not "the major factor in coastal dynamics" such as direction of sediment transport. Tr. 171:20-172:13 (Chrzastowski); Tr. 600:5 (Selegean) (same). It may be that some sediment (which may include river sediment) is lost beyond the depth of closure. See Part IV.C.2.c.ii. But the court has no evidence before it as to the quantity of river material that may be lost. Even more importantly, the evidence before the court indicates that river material would not substantially affect the sediment budget.

ii. Diversion of Sediment into Deep Water

The evidence supports the assertion that some sediment is diverted into deep water and not included in the sediment budget. Dr. Meadows testified, "There is also a significant fraction [of sediment] that moves a substantial distance away that is not accounted for. There's no practical way." Tr. 47:13-15 (Meadows); Pls.' Br. 3; see also PX 93 (1973 Report) 50 (stating that "littoral material is not accumulating along the piers

but is being diverted by the piers into deep water"); PX 22 (1974 Report) 234 ("[A] considerable quantity of littoral material is retained annually on the north side of the harbor, . . . or diverted lakeward by the harbor structures").[61] In a cross-examination colloquy concerning whether there was a point in time that the piers were partially permeable, Dr. Selegean admitted that there is a possibility that the hydraulics of the river feeding into the piers carry material "where it's deeper and it's more likely to drop off." Tr. 688:24-689:2 (Selegean). Dr. Meadows further testified that he has "seen guesses in the literature" as to how much sediment is lost offshore into deep water, and he states that it is "reasonable" to make such guesses, but he also states that "they're subject to large errors." Tr. 48:3-7 (Meadows).

Dr. Nairn addresses the view that significant amounts of sediment moves to deep water by explaining his calculations as to what occurs to sand that is diverted by the piers. Rather than reaching deep water, Dr. Nairn contends that the sand creates a bypassing shoal:

> We've got river sand coming out of the river on very high flows and we've got sand moving along the shoreline and getting pushed out or moving along here.

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[61]Plaintiffs support Dr. Meadows' testimony with reference to PX 115, a copy of an aerial "view" of the harbor which shows a discoloration adjacent to the end of the south jetty. PX 115 (Aerial View); Pls.' Br. 4; Pls.' Resp. 5. Plaintiffs' Exhibit 115 was not shown to Dr. Meadows. See Tr. passim. The date of this exhibit is unclear. A sticker was attached to the exhibit dated August 24, 2006, but it is unclear whether this pertains to the date of the photograph or the date that it was identified as an exhibit in a deposition or otherwise. See PX 115 (Aerial View). Dr. Nairn was shown this exhibit during cross examination and testified that "[w]hatever the discoloration of the water is," it seems to be moving approximately 800 feet beyond the end of the 1700-foot pier. Tr. 1310:5-1311:8 (Nairn). Dr. Nairn testified that this discoloration may "possibly" be "sediment going off the end of the pier." Tr. 1308:2-4 (Nairn). The court notes that the alleged sediment trailing off of the jetty is from the south pier and thus, is presumably not part of the calculations for littoral drift headed in a southerly direction. See PX 115 (Aerial View). The court thus considers PX 115 of limited value because, even if it indicates that some sediment is moving offshore from the south fillet, it does not show that sediment from the north fillet is also moving offshore. On the other hand, plaintiffs also refer to page 39a of the 1973 Report, an aerial photograph similar to PX 115 (Aerial View) but showing a discoloration off of the north fillet. PX 93 (1973 Report) 39a; Pls.' Resp. 5 (alleging that page 39a of the 1973 Report "clearly show[s] only a small portion [of sediment] falls fast enough [to fall in the outer harbor and] to be captured [by dredging]"). Page 39a of PX 93 was not specifically pointed out or discussed at trial, see Tr. passim; Pls.' Br. 4, and the court does not credit plaintiffs' interpretation of littoral processes based on page 39a of PX 93 made for the first time in post-trial briefing.

> What the sand tries to do once the fillet beach is full is make its way around. And in order to make its way around it, in simple terms, creates a bridge. And that bridge is a bypassing shoal. Because it needs to create a shallow enough depth where . . . the waves can break and create a current and lift up enough sand so that sand can continue to move. So it's creating a bridge in a natural way, its own bridge around the harbor. And so that's a sink. We've included that within our sediment budges. That's a loss of sand from the littoral zone.

Tr. 1161:8-20 (Nairn) (citing DX 15 (Lakebed Change Between 1907 and 1954)). In other words, some sand is lost from the littoral zone as it creates a "bridge," but that sand is not lost to deep water where there is "no practical way," Tr. 47:13-22 (Meadows), of measuring it. Moreover, Dr. Nairn states that "[w]e've included that within our sediment budget." Tr. 1161:18-19 (Nairn). The sand that "continues to move" presumably remains in the littoral zone and is accounted for. Plaintiffs do not challenge this testimony. See Pls.' Br. passim; Pls.' Resp. passim.

Dr. Nairn acknowledges that some sediment is moving to deep water when he explains during direct examination why his budget is a "a sand budget, not a sediment budget." Tr. 1214:16-17 (Nairn).

> Because it's the sand that stays on the shore and builds the beaches. The clay and the silt gets winnowed into offshore – it remains suspended and only settles in very deep water in, say, depths greater than 10 or 15 or 20 meters. . . . [I]t's lost. Important to the people that live there that it was there and it was lost, but it doesn't figure into the sand budget that I'm doing.

Tr. 1214:20-1215:1 (Nairn). In Dr. Nairn's sediment budget, which includes calculations of the net longshore transport rate and the necessary nourishment, "clay and silt" are not relevant and thus not part of the calculation. See id. This is because Dr. Nairn relies on Dr. Larson's findings to conclude that plaintiffs' properties are characterized by a "predominantly sandy shore" rather than a cohesive shore, see id. at 1213:20-1215:3 (Nairn), a point he confirms when he states that "we're only looking at the sand grain sizes. We're not looking at the finer clays and silts. They've moved further offshore." Id. at 1172:23-25 (Nairn). Dr. Larson's testimony is discussed above in Part IV.B.1.

d. Effects of the Depression South of the St. Joseph Harbor

Plaintiffs argue in the alternative that a depression south of the jetties interrupts littoral drift:

> Even if the sediment fall velocity were so great that substantial sediment is captured in the fan shaped flare, the fall velocity effect would prevent the sediment from escaping the southbound littoral drift being captured in the depression shown on PX24- 80 Figure 35. That depression is over 9,000 feet long, where the flare is about 300 feet long. . . . The huge size of the PX24 [1997 Report] - 80 depression seems not to deter defendant from concluding that the small flare catch basin captures all sediment whereas the much larger depression catches only about 50%.

Pls.' Resp. 5 (citing PX 24 (1997 Report) 18, 49, 87)). Plaintiffs argue that, even if sediment were to reach the lake bottom prior to reaching deep water, it would still be lost to the littoral zone: Most of it would not, in fact, be captured in the smaller flare at the end of the harbor but would sink into a lake bed depression just south of the harbor. See id. Once in that depression, it would not emerge, and thus it would no longer be part of sediment transport calculations. See id.

Dr. Chrzastowski testified about the depression plaintiffs refer to. Dr. Chrzastowski states that, because the depression acts as a sink, it would take 400 years of nourishment "to bring the lake bottom back up to a certain elevation." See Tr. 187:22-188:2 (Chrzastowski) (citing PX 24 (1997 Report) 80). But Dr. Chrzastowski testified that his opinion as to the 400-year projection is based on the 1997 Report, not actual evidence that he has seen, and that he is "assuming that [it] is still trapping sand based on this report." Tr. 225:1-19 (Chrzastowski) (citing PX 24 (1997 Report) 80). In fact, Dr. Chrzastowski has "never reviewed the [Nairn Report]." Tr. 175:13-16 (Chrzastowki). Dr. Nairn, on the other hand, one of the co-authors of the 1997 Report, explained in court that, at the time of the 1997 Report, he had reasoned that "sediment could get stuck in [the depression]." Tr. 1210:5-6 (Nairn). Since then, however, he has concluded that this was based on "an incorrect assumption," Tr. 1208:24 (Nairn), because a sand bar forms at the depression that "provides the pathway or the bridge for sediment to get through that . . . area." Tr. 1210:6-10 (Nairn). Dr. Nairn testified that he disagrees with his conclusion in the 1997 Report that this area "has been a sink, possibly for up to 50 percent of the coarse sediment placed in the feeder beach area." PX 24 (1997 Report) 87; Tr. 1207:12-21 (Nairn).

Plaintiffs offer no expert critique countering Dr. Nairn's more recent conclusions about the depression and in fact misunderstand defendant's position as still being in agreement with this section of the 1997 Report. See Pls.' Resp. 5. This is a technical question involving subsurface processes. Plaintiffs have not established – as it is their burden to establish – that sand passing near the depression will be lost to the littoral zone. Plaintiffs also offer no evidence to support their assertion in briefing that sediment that makes its way to the outer harbor would make it all the way to the depression rather than

fall and be dredged from the harbor. See id. The court has no basis for concluding that this sediment was not included in Dr. Nairn's calculations for sediment transport rate.

e. The 1973 Report and the Nairn Report

One hundred and ten thousand cubic yards per year was a figure adopted by the 1973 Report as the net southerly transport rate trapped by the pier. PX 93 (1973 Report) 58; Tr. 62:2-17 (Meadows); Def.'s Br. 13. The 1973 Report was described by plaintiffs' expert, Dr. Meadows, without contradiction, as "the first credible look at the St. Joseph Harbor structures in estimating the total amount of material trapped by the structures." Tr. 80:19-23 (Meadows). Plaintiffs argue, and defendant does not disagree, that "the Corps [uniformly] acknowledged" the accuracy of this figure "until this litigation." Pls.' Mem. 1; see Def.'s Br. 2. All of the reports studying beach erosion around St. Joseph harbor prior to this litigation, several of them co-authored by Dr. Nairn, indicate that the net littoral drift is 110,000 cubic yards per year. PX 93 (1973 Report) 59; PX 32 (Interim Report 1975-1984) 5; Tr. 420:17-20 (Thompson) (stating that he considered 110,000 cubic yards the figure to be followed at the time of the Interim Report 1975-1984); PX 22 (1974 Report) 235; PX 23 (1996 Report) 2; PX 24 (1997 Report) 17; PX 41 (1999 Report) 4. This blockage was considered by the Corps to be causing 30% of the erosion south of St. Joseph Harbor. PX 93 (1973 Report) 32; PX 22 (1974 Report) 235; PX 41 (1999 Report) 4; see also Tr. 63:5-12 (Meadows) (testifying that, according to the 1973 Report, 30% of the total loss of sediment was 110,000 cubic yards per year) (citing PX 93 (1973 Report) 59); Tr. 655:16-21 (Selegean) ("[Thirty] percent of that total erosion the author claims [316,000 cubic yards per year] is due to the harbor.") (citing PX 93 (1973 Report) 32). In fact, the only report to support a different figure is Dr. Nairn's "Assessment of the Causes of Erosion in the Vicinity of St. Joseph Harbor, Michigan" (Nairn Report) prepared in anticipation of this litigation for the price of approximately one million dollars. Tr. 1327:17-18 (Nairn); Defendant's Exhibit (DX) 1 (Nairn Report) 3-63 to -65; Tr. 1144:9-22 (Nairn); Pls.' Resp. 12.

The Nairn Report, plaintiffs argue, is a "partisan study, the sole purpose of which was to defeat plaintiffs' litigation claims." Pls.' Br. 43; Def.'s Resp. 7. Defendant counters that plaintiffs have no rebuttal to Dr. Nairn's explanations for the substantive differences between his earlier work and the work that he conducted for this litigation. Def.'s Resp. 7. Defendant also points out that plaintiffs do not dispute that Dr. Nairn "is highly regarded by plaintiffs' experts for his competence" or that his sediment budget analysis was conducted "in a manner approved and endorsed by plaintiffs' experts." Id. (citing Def.'s Br. 22); see also Def.'s Br. 14 (citing Tr. 143:24-144:6 (Meadows)). Defendant argues, based on the testimony, that plaintiffs's experts did not disagree with Dr. Nairn's data, methodology, or computer modeling, nor did they opine that Dr. Nairn's

results were incorrect. Def.'s Br. 11. Defendant argues that Dr. Meadows, plaintiffs' expert witness, believes that Dr. Nairn's studies were conducted properly, that the results were valid, and that a longshore transport rate of 50,000 to 60,000 cubic yards per year is reasonable. Id. at 14 (citing Tr. 143:24-144:6, 146:15-151:13 (Meadows)).[62]

Defendant also argues that plaintiffs did not "provide any testimony from their experts that took exception with or found a confidence level of plus or minus [twenty-five] percent [the confidence level contained in the Nairn Report, DX 1 (Nairn Report) 2-28] problematic." Id. at 14 (alteration added). On the sediment budget in general, defendant states that Dr. Nairn considered all sources of sediment and sinks for the area, that he "approached his analysis trying to make no assumptions, trying to err on the side of the plaintiffs, and trying to come to conclusions using several different approaches to ensure checks and balances," and that he tested the results of the modeling calculations. Id. at 12 (citing Tr. 1120:6-1122:15, 1114:2-22, 1126:22-25 (Nairn).

Defendant argues that the Nairn Report presents a more accurate calculation of the longshore transport rate than do all of the earlier reports. Mr. Thompson testified that net littoral drift in any area can be calculated in "several ways" and "over time there would be changes as well just as improvements in the data and procedures came about." Tr. 423:25-424:6 (Thompson); see also Tr. 1114:18-22 (Nairn) ("[W]e just try to make sure that we don't base everything on one single methodology . . . . So that we have checks and balances in our procedures."). Defendant cites to Mr. Thompson's testimony to support Dr. Nairn's calculations, Def.'s Br. 13, which were done approximately thirty years after the calculations that yielded a transport rate of 110,000 cubic yards per year, compare PX 93 (1973 Report) 58, with DX 1 (Nairn Report) 3-63 to -65. Dr. Nairn employed five different calculations based on three different approaches. DX 1 (Nairn Report) 3-63 to -65; Tr. 1141:23-1143:8, 1144:9-22 (Nairn); Def.'s Br. 13. Dr. Nairn's calculations yielded the following results: 40,500 cubic yards per year, 71,500 cubic yards per year, 48,000 cubic yards per year, 40,000 cubic yards per year, and 50,000 cubic yards per year. DX 1 (Nairn Report) 3-63 to -65; Def.'s Br. 13. Dr. Nairn averaged those figures to determine the longshore transport rate for use in his sediment budget, concluding that the rate equals approximately 50,000 cubic yards per year. Tr. 1144:9-22 (Nairn); Def.'s Br. 13-14. The Nairn Report warns that there might be a margin of error of 25%, see DX 1 (Nairn Report) 2-28, but Dr. Nairn testified that he thinks the real figure is less than a twenty-five percent difference from his calculation of 50,000 cubic yards per year, Tr. 1334:13-14 (Nairn). Defendant emphasizes that Dr. Nairn's five

[62]Defendant also claims that Dr. Nairn's longshore transport rate was corroborated by the rate calculated by Dr. Meadows' earlier work on behalf of the University of Michigan. Def.'s Br. 22. However, defendant failed to cite to a source that would support this assertion. See id.

different calculations relied upon more recent data and improved technology than the calculations conducted in the 1973 Report. Def.'s Br. 22.

Plaintiffs argue that "[Dr.] Nairn doesn't explain . . . how the sand accumulation rate can be known when there is so much disagreement on the subject." Pls.' Resp. 13. That there is disagreement on the subject is clear: Dr. Chrzastowki expressed doubt as to the experts' view that the fillets "have reached equilibrium."[63] Tr. 200:1-9 (Chrzastowski).[64] The Nairn Report, on the other hand, calculates that the south fillet beach "stopped growing in the long term sense" since approximately the 1940s. Tr. 1158:14-1159:7 (Nairn).

Defendant argues that Dr. Nairn "demonstrated that the 1973 [Report] figure was flawed and overstated the true [longshore transport] rate because of issues with insufficient information regarding the shoreline and fillet growth between 1907 and 1954." Def.'s Br. 22 (citing Tr. 1145:2-1150:25 (Nairn)). Dr. Nairn explained during his testimony that, in the period between 1907 and 1954, which was the snapshot in time used by the authors of the 1973 Report in calculating its longshore transport rate, the fillet beach was growing at a faster rate than the net rate. Tr. 1145:22-24 (Nairn). His underlying theory for that statement is that the fillet beach, when it nears fullness, receives the full amount of sand from the north but not the full amount from the south because of wave defraction.[65] Id. at 1146:24-1147:12 (Nairn). Instead, the southerly

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[63]Dr. Chrzastowski testified that vertical accumulation could be seen on the field trip prior to trial. Tr. 200:1-9 (Chrzastowski). As noted above in footnote 10, the site visit to which Dr. Chrzastowski refers did not provide occasion for testimony or evidence. Order of Apr. 12, 2007, 1; Pretrial Tr. 162:4-10. However, as an expert, Dr. Chrzastowski may use sources that are inadmissable as evidence for the basis of his opinions. Fed. R. Evid. 703 ("If of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence in order for the opinion or inference to be admitted.").

[64]Plaintiffs argue that Dr. Meadows opined that the "fillet on the north side and on the south side continue to grow." Tr. 64:24-65:1 (Meadows); Pls. Resp. 11. However, the expert opinion underlying plaintiffs' argument was stated at trial over objection by defendant that "this is an opinion of his that does not appear in his expert report that he has submitted to the defendants." Tr. 67:15-17 (Meadows). After hearing the objection, plaintiffs withdrew the question. Id. at 71:19-21 (Meadows). The court therefore disregards the argument as lacking a basis in the evidence.

[65]Wave defraction is a process whereby the energy from waves spreads out. See Tr. 1146:24-1147:12 (Nairn).

waves bring the sand back out into the harbor. Id. at 1146:10-14 (Nairn). Dr. Nairn stated that the individuals who calculated the longshore transport rate in the 1973 Report did not consider that the fillet beach grew at a faster rate than the net rate. Id. at 1148:2-5 (Nairn). Dr. Nairn also stated that the authors of the 1973 Report erred in using 1907-1954 as a snapshot to calculate the longshore transport rate because data demonstrated that the shoreline in 1897 and 1914 was further lakeward than it was in 1907. Id. at 1148:10-14 (Nairn). Thus, Dr. Nairn concludes that the shoreline in 1907 "is not a good average snapshot[] in that[] it was more eroded than the average conditions." Id. at 1148:16-17 (Nairn). Dr. Nairn had a parallel criticism for the shoreline in 1954: He stated at trial that, in comparison to the shorelines in 1973 and 1985, the shoreline in 1954 appears to be overly accreted. Id. at 1149:10-14 (Nairn). In sum, Dr. Nairn asserted that, in order to calculate the longshore transport rate, one needs an accurate fillet beach growth rate and that that calculation must derive from "the most appropriate line, the most appropriate growth period," which he faults the authors of the 1973 Report for failing to do. Id. at 1150:10-25 (Nairn).

Defendant presented another witness at trial, Dr. Selegean, who demonstrated through a series of calculations that a component of the longshore transport rate utilized by the 1973 Report was in error. See Def.'s Br. 22 n.9. Dr. Selegean testified that the authors of the 1973 Report calculated the longshore transport rate by adding the amount of sediment that the north jetty trapped and the amount of sediment that traveled around the north jetty and became trapped in the outer harbor, which ultimately was dredged. Tr. 668:18-669:1 (Selegean). Dr. Selegean conducted a number of calculations during the trial to demonstrate that the amount of sediment trapped against the north jetty, which the authors of the 1973 Report had computed to be 75,000 cubic yards/year, was overstated and that the correct amount was closer to 40,000 cubic yards/year. Id. at 658:9-669:9 (Selegean); see also Def.'s Br. 22 n.9.

As discussed above, Part III.C, the fact that Dr. Nairn was paid for his services as an expert is not, without more, evidence of bias. As correctly pointed out by plaintiffs, the evidence up to the time of litigation supports that 110,000 cubic yards per year is the southerly littoral drift trapped by the jetties. On the other hand, despite the number of Corps Reports that support 110,000 cubic yards per year, that figure is based on data selected for a single study. In light of the improvement in data collection, selection, and analysis, that figure may be corrected by more recent analyses. See Tr. 423:25-424:6 (Thompson) ("[C]ertainly . . . over time there would be changes as well just as improvements in the data and procedures came about.").

Dr. Nairn explained credibly and in detail what he perceived to be errors in the 1973 Report and its calculations. In support of his own calculations, Dr. Nairn in clear

testimony "identif[ies] all the sources of sediment and all the sinks for sediment." Tr. 1120:6-1122:8 (Nairn); Def.'s Br. 12. Dr. Nairn used several approaches to provide "checks and balances in our procedure." Tr. 1114:18-22, 1126:22-25 (Nairn); Def.'s Br. 12, 14. The court finds nothing unreasonable about the 50,000 cubic yards per year of interruption in littoral drift presented in Dr. Nairn's testimony and the Nairn Report.

Plaintiffs presented no expert testimony refuting Dr. Nairn's findings. In fact, Dr. Meadows acknowledges that he has not personally calculated the net transport rate, Tr. 46:5-16 (Meadows), and that he does not have "a number in mind" as to the correct figure, Tr. 148:12 (Meadows), having relied on both of the extremes in his various reports, Tr. 80:19-81:1 (Meadows) ("I use both [Nairn's Report and the 1973 Report] in forming my opinion."); see also Tr. 62:10-15 (Meadows).

Dr. Meadows also testified that he believes that Dr. Nairn tried to do his analysis in "a fair, objective, [and] competent manner," Tr. 115:23-116:3 (Meadows), that Dr. Nairn's work for this litigation was extensive, and that the methods used were sound. Tr. 143:24-144:6 (Meadows); Def.'s Br. 14; Def.'s Resp. 7. Dr. Chrzastowski acknowledged that Dr. Nairn's and Dr. Larson's reports contain recently derived data that he did not have available when preparing his own report. Tr. 211:18-23 (Chrzastowski). In fact, Dr. Chrzastowki "never reviewed the [Nairn Report]." Id. at 175:13-16 (Chrzastowki). No expert witness even attempted to impeach the Nairn Report. See Tr. passim.

Defendant's position is supported by a scientific study directly addressing the issues in this case, including extensive explanations of the methodology employed and clearly presented by an acknowledged expert, whereas plaintiffs' position is supported by calculations that date back over three decades. Plaintiffs present no evidence, testimonial or documentary, that discredits Dr. Nairn's calculations, while defendant presents detailed testimony that discredits the calculations in the 1973 Report. Plaintiffs' experts acknowledge the soundness of the methodology employed in the Nairn Report, whereas defendant's experts explain the errors in the 1973 Report. The estimated blockage of the net sediment transport calculated in the 1973 Report, although an admission by defendant, has been shown by the preponderance of the credible evidence, to be incorrect. The court holds that the preponderance of the credible evidence establishes that the piers interrupt net southerly sediment transport in the area of St. Joseph Harbor at the rate of 50,000 cubic yards per year.

D. Effective Placement of Nourishment Material

Plaintiffs quote the following sentence from page 3 of the 1999 Report: "The beach nourishment program is designed to mitigate [the] disruption [of littoral processes]

by replacing that material." PX 41 (1999 Report) 3; Pls.' Br. 11.[66] For the beach nourishment program to be effective, the sediment replaced by defendant should be placed such that "the sand would have reached the plaintiffs' zone." Pls.' Br. 11; Tr. 181:14-22 (Chrzastowki).

Plaintiffs suggest that the use of Lions Park as a feeder beach, see DX 34 (St. Joseph Dredging); Pls.' Br. 20, is problematic because of the direction of the littoral transport in that area. See Pls.' Br. 20-22. Plaintiffs acknowledge that the wave-dominated coast, Tr. 171:18-24 (Chrzastowski), has a net southerly direction of sediment transport, Tr. 172:6-9 (Chrzastowski), Pls.' Br. 20; PX 23 (1996 Report) 9; Tr. 1277:4-13 (Nairn). However, plaintiffs point to evidence that the "predominant direction of wave approach is from the southwest," PX 23 (1996 Report) 9; Tr. 1277:4-13 (Nairn); Pls.' Br. 20, implying that even though the predominant wave energy from the north and northwest create a net southerly littoral drift, "[n]orthward transport also occurs." PX 23 (1996 Report) 9; Tr. 1277:4-13 (Nairn); see Pls.' Br. 20. Plaintiffs point out that the 1999 Report indicated that the Corps did not have the ability accurately to forecast longshore transport direction because of its difficulty in forecasting wind and wave conditions a year in advance. PX 41 (1999 Report) 4; Tr. 441:5-12 (Thompson); see Pls.' Br. 20.[67] More specifically, plaintiffs argue that the Corps "is not capable of forecasting alongshore transport direction for any year." Pls.' Br. 20. "Conditions for any year . . . can change significantly." PX 41 (1999 Report) 4. The implication of plaintiffs' argument is that there is variation in the direction of the littoral transport along the shoreline close to the harbor due to wind patterns, the net long-term longshore transport direction notwithstanding.

Based on the testimony from their expert witness, Dr. Chrzastowski, plaintiffs argue more specifically that the location of the feeder beach is inadequate because it exists on a "zone of drift divergence" that prevents approximately half of the nourishment placed at Lions Park from reaching plaintiffs' zone. See Pls.' Br. 20-22; Tr. 181:24-25 (Chrzastowski). "[T]he purpose of a feeder beach is to provide sand to the downdrift shore to compensate for any littoral transport that has been blocked by the jetties." Tr.

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[66]The court presumes that plaintiffs are drawing on the 1999 Report to describe the methods used by the Corps to mitigate erosion. The court does not understand this basic information to be in dispute. However, all testimony relating to this portion of the 1999 Report at trial involved gross littoral drift and not the process of mitigation. See Tr. 498:25-501:19 (Thieme); 437:1-19 (Thompson); Tr. 697:25-698:9 (Selegean); Tr. 711:25-712:18 (Schweiger).

[67]The court notes that Mr. Thompson could verify the Corps' activities only up to his retirement in 2003. Tr. 442:4-9; 397:17-19 (Thompson).

181:15-17 (Chrzastowki). This means that "you want to make sure that you get that sediment into a zone that has a net transport in the southerly direction." Tr. 181:20-22 (Chrzastowki). According to Dr. Chrzastowski, although the shoreline around St. Joseph generally has a long-term littoral direction to the south, Tr. 172:6-9 (Chrzastowski), Pls.' Br. 20; PX 23 (1996 Report) 9; Tr. 1277:4-13 (Nairn), the area of Lions Park specifically is at a zone of divergence, which is an area "where there's near equal opportunity for sediment going either north or south." Tr. 181:24-25 (Chrzastowki). Dr. Chrzastowki also testified that the zone of divergence is "transitional," without clear boundaries. Tr. 218:15-24, 220:17-19 (Chrzastowki). Nevertheless, Dr. Chrzastowski's testimony supports the conclusion that, even if the precise dimensions of this zone are undetermined, the Lions Park feeder beach is located within the zone. See Tr. 181:22-24 (Chrzastowki). Dr. Chrzastowki testified that he used only visual evidence for his calculations on the entrapment of sediment at both north and south fillet, Tr. 200:9-25 (Chrzastowki), without any "mathematical analysis to determine whether there was an increase in dredging because of a south to north transport." Tr. 215:6-10 (Chrzastowki). Further, Dr. Chrzastowki stated that the 50-50 ratio is based "on the balance of the[] two wave approaches," not actual sediment measurements. Tr. 217:2-13 (Chrzastowki). Finally, Dr. Chrzastowski testified that, because of his theory on the zone of divergence, he agreed with the 1997 Report, which advised that nourishment be placed further south than the current feeder beach. PX 24 (1997 Report) 88, 90; Tr. 184:11-24, 179:16-24 (Chrzastowki).[68]

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[68]Plaintiffs also rely on Mr. King's testimony as evidence of the ineffectiveness of the placement of the dredged material. Pls.' Br. 19-20. Mr. King contracts with the Corps to do maintenance dredging at the end of the piers. Tr. 330:10-12, 331:4-13 (King); Pls.' Br. 19. Mr. King testified from a record of construction dated April 28, 2005, and his recollection of an incident where his company had to re-dredge the St. Joseph outer harbor because a storm had created a shoal after the initial dredging job. PX 116 (Record of Construction FY05 Dredging St. Joseph Harbor, Michigan (2005 Record of Construction)); Tr. 334:1-15 (King); Pls.' Br. 19-20. Plaintiffs claim that "King testified that his contracts with the Corps for dredging had no weather provision requiring slurry pipe nourishment of Lions Park only when the waves were southbound," Pls.' Br. 20, implying that the 44,089 cubic yards of sediment that Mr. King's company removed from the entrance area of the harbor were from "[n]orthbound" activity, see PX 116 (2005 Record of Construction); Pls.' Br. 20. The court understands plaintiffs to be presenting this testimony as evidence of the alleged zone of divergence that moves sediment north. However, plaintiffs do not identify where in the transcript Mr. King discusses whether his contracts for dredging hinged on the direction of the waves, Pls.' Br. 19-20, and the court did not identify any such testimony in the transcript, Tr. 329:14-345:10 (King). The technical interpretation by counsel of Mr. King's testimony, made for the first time in post-trial briefing, is disregarded by the court.

Dr. Nairn is aware of Dr. Chrzastowski's analysis of a zone of divergence and does not wholly disagree with it, but he does disagree about its effect on the efficacy of the nourishment program. Def.'s Resp. 10-11. Dr. Nairn acknowledges that "there is a small area of divergence" approximately "midway along the [Lions Park] fillet beach." Tr. 1177:2-6 (Nairn) (citing DX 20 (Nearshore Currents Under NW Storm Event (HydroSed model results)).[69] He also testified that, especially during storm conditions, sand from the feeder beach would move north. Id. at 1180:19-22 (Nairn) (citing DX 21(Nearshore Currents Under SW Storm Event (HydroSed model results));[70] see also id. at 1177:10-21 (Nairn). However, Dr. Nairn's view is that this sand would not be permanently trapped at the south fillet beach. Id. at 1180:23-1181:1 (Nairn). Instead, "water flows into that area and then it's got to go out somewhere, so it flows out along the south jetty and rejoins the bypassing shoal." Id. at 1177:19-21 (Nairn). From previous testimony on bypassing shoals, whose purpose is to create a "bridge" by which "sand can continue to move. . . . around the harbor." Id. at 1161:8-20 (Nairn), and from the arrows on DX 20, which "show the current patterns," Id. at 1175:23 (Nairn) (citing DX 20 (Nearshore Currents Under NW Storm Event (HydroSed model results)), the court understands Dr. Nairn's view to be that once sand-transporting water "rejoins the bypassing shoal," it eventually makes its way back south and into the littoral zone. Id. at 1177:21. Thus, Dr. Nairn "believe[s] that all the sediment from the feeder beach . . . does reach the south shore [where plaintiffs' properties are]" and that there is little or no loss from the drift, or zone, of divergence. Id. at 1182:20-1183:2 (Nairn). As evidence of this shoal, Dr. Nairn states that the south "fillet beach is not growing. It hasn't grown since 1945 . . . ." Id. at 1181:2-4 (Nairn). Nor has there been an "appreciable increase in the amounts of dredging from the outer harbor." Def.'s Resp. 11; see Tr. 1181:19-1182:4 (Nairn).

In their argument about the ineffectiveness of the placement of the dredged material, plaintiffs revisit PX 115 (Aerial View). See Part IV.C.2.c.ii (discussion of

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Dr. Meadows testified that, in his opinion, Mr. King's company dredged material that had gone north from the nourishment beach, Tr. 84:3-6 (Meadows), but the court sustained an objection to this testimony based on the facts that Dr. Meadows did not include these conclusions in his expert report, and was not in possession of PX 116 during the drafting of his expert report, Tr. 84:18-85:22 (Meadows).

[69]A copy of DX 20 is also found on page 3-59 of the Nairn Report. Tr. 1174:17-19 (Nairn); compare DX 1 (Nairn Report) 3-59, with DX 20 (Nearshore Current Under NW Storm Event (HydroSed model results)).

[70]A copy of DX 21 is also found on page 3-61 of the Nairn Report. Tr. 1179:7-1180:3 (Nairn); compare DX 1 (Nairn Report) 3-61, with DX 21 (Nearshore Current Under SW Storm Event (HydroSed model results).

diversion of sediment into deep water). Nevertheless, as explained above in footnote 61, Part IV.C.2.c.ii, PX 115 is not sufficient evidence to prove that the sand necessary for nourishment of plaintiffs' zone is being diverted into deep water. Although Dr. Chrzastowski relied on the 1997 Report to support his opinion to that effect, Tr. 184:24, 179:16-24 (Chrzastowki) (citing PX 24 (1997 Report) 88, 90), it is not at all clear to the court that the main reason that the 1997 Report recommended placement of nourishment further south is because of a zone of divergence. The 1997 Report did conclude that "the area where a supply of sediment is most urgently required is only receiving 50 percent or less of the historic supply rate of coarse sediment," PX 24 (1997 Report) 90, and that "[i]t would be much more effective to place the entire annual allotment of beach nourishment . . . south of Lines R22 or R23 where it would be 100 percent effective in supplying the downdrift shores," id. at 88. Dr. Nairn, co-author of the 1997 Report, explained how, at the time that it was written, it was believed that there was a depression south of the feeder beach that "sediment could get stuck in." Tr. 1210:5-6 (Nairn). Because of this depression, "up to 50 percent of the coarse sediment placed in the feeder beach area" could, according to the 1997 Report, be trapped. PX 24 (1997 Report) 87; Tr. 1207:12-21 (Nairn). Indeed, Lines R22 and R23 are south of this "[s]ediment [s]ink, " PX 24 (1997 Report) 82; also, the section in the 1997 Report to which Dr. Nairn refers is the same section that Dr. Chrzastowski refers to as support for the theory of the zone of divergence, compare Tr. 1207:12-1210:10 (Nairn) (citing PX 24 (1997 Report) 87), with Tr. 184:24, 179:16-24 (Chrzastowki) (citing PX 24 (1997 Report) 88, 90). Dr. Chrzastowski also noted and discussed the depression referred to in the 1997 Report. Tr. 187:22-188:9 (Chrzastowski) (citing PX 24 (1997 Report) 80).

There is brief mention in the 1997 Report that "[b]y moving the feeder beach to the south, the sedimentation rate experienced in the navigation channel should be significantly reduced," PX 24 (1997 Report) 90, suggesting that some sediment from the feeder beach goes north and into the navigation channel. The only other reference in this section of the 1997 Report about northerly transport states the following:

> The fillet beach south of the harbor is currently stable or slightly accreting. During southwest storms, this sector receives sediment from erosion in the feeder beach area. It would appear that the fillet has reached its maximum extent and that any additional sand transported northwards eventually makes its way into the navigation channel where it is deposited, and later dredged.

Id. at 84. However, as far as the court could discern, there is no further evidence in this section of the 1997 Report that a zone of divergence exists outside of storm conditions. See PX 24 (1997 Report) 77-90.

Dr. Nairn's conclusions are based on the most complete studies in evidence and are never refuted by plaintiffs' experts. Part IV.C.2.e. Dr. Chrzastowki, in comparison, used only visual evidence for his calculations, Tr. 199:23-200:25 (Chrzastowki), and he did not perform any "analysis of the dredging records to see whether or how they confirmed [his] analysis" that the sand is going "offshore . . . along the south jetty and into the jetty entrance," id. at 216:10-18 (Chrzastowki), or to confirm his calculation that half of the nourishment is lost to northern transport, see id. at 216:15-24 (Chrzastowki). Dr. Chrzastowki could not refute Dr. Nairn's analysis because he has not "seen his new report." Id. at 216:20 (Chrzastowki). Furthermore, Dr. Chrzastowki acknowledged that it is "certainly possible" that "sand that's transported northward toward the south fillet would ultimately be returned to the south by a southward transport along an outer sand transport pathway, like a bypassing shoal." Id. at 232:12-17 (Chrzastowki). The court concludes that defendant has supported, by a preponderance of the credible evidence, its position that a bypassing shoal helps transport most[71] of the nourishment placed at Lions Park to plaintiffs' zone.

E. Additional Testimony

1. Testimony of Six Plaintiffs

Plaintiffs highlight in their briefing the factual testimony of six plaintiff witnesses. Pls.' Br. 13-19. Although plaintiffs explain the purpose only of Ms. Carole L. Ehret's testimony, "to document the condition of the beach," Pls.' Br. 17, the apparent import and purpose of the testimony of the other plaintiff witnesses was the same, see Pls.' Br. 13-19.

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[71]Defendant sought to impeach Dr. Chrzastowski's testimony by seeking an admission from him that the 50-50 ratio is based "on the balance of the[] two wave approaches" rather than actual sediment measurements. Tr. 217:2-13 (Chrzastowki). There is evidence to indicate that wave movement and energy have a significant effect on sediment transport, see, e.g., Part II supra, such that Dr. Chrzastowski's conclusion is not unreasonable because of this correlation. Although plaintiffs have failed to meet their burden to persuade the court of a divergence that substantially diminishes the effectiveness of the nourishment program, this holding is not based on the fact that Dr. Chrzastowski relied on inferences from the wave approaches.

The court also notes that, in admitting to the possibility of a bypass shoal, Dr. Chrzastowki was clear that the sand headed south because of the bypass shoal would help reduce erosion offshore, not on the shoreline. Tr. 217:18-25 (Chrzastowki). This contrasts with Dr. Nairn's testimony that "all the sediment from the feeder beach . . . does reach the south shore [where plaintiffs' properties are]." Tr. 1182:24-25 (Nairn).

Ms. Marsha Wineberg testified that, since purchasing her property in 1975, she has lost lake-front property measuring 210 feet wide, 100 feet deep, and 85 feet high. Tr. 244:15-245:1 (Wineberg); PX Summary Tab 4, 61; Pls.' Br. 14. Beginning in 1984, Ms. Wineberg attempted to protect her property by installing shoreline protection consisting of concrete blocks extending across the width of the property. Tr. 245:11-19 (Wineberg); Pls.' Br. 14. Ms. Wineberg testified that her current shoreline protection seems to be working, but she also acknowledged that currently the lake is low. Tr. 251:22-252:1 (Wineberg); see also. Tr. 783:1-7 (Miller) (testifying that his current shoreline protection is "working for now," but only because the lake is low).[72]

The other five plaintiff witnesses, although not providing the precision of Ms. Wineberg's measurements in their testimony, had experiences similar to and consistent with Ms. Wineberg's experience of property loss due to erosion and attempts at protection. Tr. 886:1-893:16 (Marzke); Pls.' Br. 14-15; Tr.776:6-785:23 (Miller); PX Summary Tab 4, 31-33; Pls. Br. 15-16; Tr. 274:7-291:6 (Chapman); PX Summary Tab 3; Pls.' Br. 16; Tr. 509:2-518:3 (Melcher); PX Summary Tab 2, 1-4, 11-14; Pls.' Br. 16-17;[73] Tr. 738:1-774:6 (Ehret); PX Summary Tab 1; PX 74Y; PX 74Z; PX 74AA; Pls.' Br. 17-19. A common theme was the futility of many of plaintiffs' attempts at shoreline protection. Tr. 888:4-7 (Marzke); PX Summary Tab 4, 50; Pls. Br. 14-15;[74] Tr. 778:8-10 (Miller); Pls.' Br. 15; Tr. 280:1-10 (Chapman); Pls.' Br. 16; Tr. 511:21-512:2, 514:13-15 (Melcher); PX Summary Tab 2, 11-12; Pls.' Br. 16-17; Tr. 752:13-15 (Ehret); PX Summary Tab 1, 29. There is plaintiff-witness testimony stating that high lake levels and violent waves contributed to erosion of their property, Tr. 894:4-9 (Marzke); Tr. 309:11-

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[72]The Michigan Department of Environmental Quality acknowledged the erosion problem, warned of prospective property loss over the next 60 years, and outlined new setback requirements in a February 9, 2007, letter. PX Summary Tab 8; Tr. 245:20-246:11; PX 135; Tr. 271:6-12; Pls.' Br. 14. Plaintiffs cite this letter as evidence of "prospective damage liability." Pls.' Br. 35; Pls.' Mem. 4. Of course, future damages are outside the scope of a trial focused solely on liability.

[73]Plaintiffs emphasize in their briefing Mr. Melcher's testimony of "[a] lot of wind blown sand" on the sidewalks of Silver Beach. Tr. 515:18-517:1 (Melcher); PX Summary Tab 2, 15-20; Pls.' Br. 17 ("Winter blown sand."). Without explanatory testimony as to the import of this evidence, the court is not in a position to use it in addressing the issues in this case.

[74]Plaintiffs refer to a "supplemental aerial photo from 1977" that Mr. Marzke used in his testimony, Pls.' Br. 14, but this photograph was not admitted into evidence, Tr. 885:8-25 (Marzke).

15 (Chapman), but some also pointed out that these were not the only factors that resulted in erosion, Tr. 894:4-9 (Marzke); Tr. 519:7-9 (Melcher).[75]

[75]Ms. Chapman – a plaintiff witness employed as a librarian, Tr. 291:7-8 (Chapman), who has completed a Master's in Library Science, Tr. 274:25 (Chapman) – testified that during her walks along the shoreline around St. Joseph, she found "fossils that we never found before." Tr. 296:6-8 (Chapman). Plaintiffs present this testimony as evidence of the disappearing shoreline because, they assert, these fossils were "uncovered by the disappearing littoral sand." Pls.' Br. 16. Similarly, Ms. Ehret – a plaintiff witness who completed a Bachelor of Arts in English literature in 1953 and a geology class in her freshman year of college, Tr. 737:11-17 (Ehret); Pls.' Br. 17-18 – testified that her son found a Hopewellian arrowhead on her beach property in the mid-1960s, Tr. 756:3-14 (Ehret); Pls.' Br. 18. Ms. Ehret further testified that the date of the arrowhead given to her by the Indian Museum in Coloma, Michigan, indicates that "our beach had been static from 1,000 B.C. to 1964." Tr. 756: 9-20 (Ehret).

Defendant objected to some of plaintiffs' questions to Ms. Chapman, stating that defendant has "no problem with Ms. Chapman testifying about what she has found and what it looks like, but to the extent she's going to opine on the processes that got the shells there, [defendant has] an objection to that" because Ms. Chapman was not qualified as an expert. Tr. 299:1-6 (Chapman). The court sustained that objection. Tr. 299:7 (Chapman). The Federal Rules of Evidence (FRE) limit lay opinion testimony to inferences rationally based on the perception of the witness, but that do not venture into "scientific, technical, or other specialized knowledge." Fed. R. Evid. 701. The court recognizes that Ms. Chapman and Ms. Ehret have spent many years on the shoreline around St. Joseph as percipient witnesses and can relate their experiences as evidence for the court to consider. Id. at 602. The court also recognizes that both Ms. Chapman and Ms. Ehret conducted research as to their findings and possess the education to reach an intelligent layman's interpretation of that research, but because they have not been qualified as experts in the current litigation, Pls.' Wit. 27-28, the court cannot consider their opinions as evidence of the processes that placed the items they found on the beach. See Fed. R. Evid. 701. Without expert testimony or other evidence to explain the findings of ancient arrowheads and fossils on the shore, Tr. passim, the court cannot draw any scientific conclusions as to the significance of these findings. Similarly, the court cannot consider Ms. Ehret's testimony on the alleged recession of the lake bed along the Lake Michigan shoreline, which plaintiffs also argue in their briefing. Pls.' Br. 25.

Nor can the court consider PX 77, a copy of a book about the geology of Michigan, which was introduced into evidence by Ms. Ehret, Tr. 763:12-23 (Ehret), as an authoritative account of the geology of Michigan. As an initial matter, this document falls under the category of hearsay because it is "a statement, other than one made by the declarant while testifying at the trial or hearing, offered in evidence to prove the truth of the matter asserted." Fed. R. Evid.. 801. Generally speaking, hearsay is not admissible. Id. at 802. There are certain exceptions to the hearsay rule, whereby evidence is not excluded even though the declarant is available as a witness. Id. at 803. Learned treatises fall under this exception. Id. at 803(18). A "learned

treatise" is a treatise, periodical, or pamphlet on the subject of history, medicine, or other science or art. Id. As noted by defendant in an objection, a technical book concerning the geology of Michigan clearly falls under this category. See Tr. 764:23-25 (Ehret).

Evidence must be authenticated or identified prior to being admitted. Fed. R. Evid 901(a). For a learned treatise to be admitted as documentary evidence, it must be established as a reliable authority by the testimony of the expert who relied upon it or to whose attention it was called. Id. at 803(18); United States v. Turner, 104 F.3d 217, 221 (8th Cir. 1997) (holding that a trial court did not abuse its discretion by refusing to take judicial notice of several medical texts and refusing to permit trial counsel to read to the jury from these texts because "there was no expert testimony establishing the texts as authoritative"); Moore v. Matthews, 445 F. Supp. 2d 516 (D. Md. 2006) (holding that, in a negligence case involving a jet ski accident, there was insufficient evidence to authenticate a treatise pursuant to Federal Rule of Evidence 901 and establish it as a "learned treatise" pursuant to Federal Rule of Evidence 803(18) without an expert to attest to its authority). Not being a qualified expert, Ms. Ehret cannot establish the authority of this evidence as a learned treatise. There was discussion at trial to the effect that PX 77 would be authenticated by another witness, Mr. Jannereth, Tr. 766:24-767:21, but Mr. Jannereth did not discuss this exhibit, Tr. 919:200-953:15 (Jannereth).

Ms. Ehret may read PX 77 to the finder of fact, as she did at trial, Tr. 764:8-20 (Ehret); Pls.' Br. 18, "but the statements themselves may not be admitted as documentary evidence unless they are admissible under some other exception to, or exclusion from, the hearsay rule." Matthew Bender 1-6 Fed. Evid. Practice Guide § 6.06(18). The only other exception that is applicable in this case is to admit PX 77 as an ancient document. Fed. R. Evid.. 803(16). An ancient document must be "in such condition as to create no suspicion concerning its authenticity," "in a place where it, if authentic, would likely be," and have "been in existence 20 years or more at the time it is offered." Id. at 901(b)(8). Printed in 1946, PX 77 had been in existence for more than 20 years at the time of trial. PX 77 (Occasional Papers for 1946 on the Geology of Michigan). Ms. Ehret testified that she obtained her copy through "an antique bookshop," Tr. 763:14-16 (Ehret), a likely place for an old book to be. The copy of the book presented as PX 77 and the actual book held by Ms. Ehret at trial, insofar as the court could discern, presented no suspicions on their face as to their authenticity. Ms. Ehret therefore read excerpts from PX 77 to the court as an ancient document. Tr. 765:1-3 (Ehret). The court ruled that "quotations from PX 77, the Court is admitting under [FRE 803(16)] as a statement in an ancient document to the extent of what was read into the record." Tr. 774:9-13. Although plaintiffs never moved to admit the entirety of PX 77 into evidence, Tr. passim; see Pls.' Br. 18 (PX 77 was "largely read into the record"), the court ADMITS PX 77 as an ancient document for purposes of completeness.

However, in considering PX 77 as an ancient document through Ms. Ehret's testimony, the court will not rely on its contents as evidence of the geology of Michigan. Plaintiffs' Exhibit 77 is an ancient document on which Ms. Ehret relied on for her views, which the court

Mr. Lloyd Richard Marzke also testified that neither he nor any of his neighbors north of the jetty, where he moved after leaving his property south of the jetty, have shore protection, implying that shore protection is not necessary in this area. See Tr. 7893:7-15 (Marzke); Pls.' Br. 15. Plaintiffs stated in their pretrial briefing, "The construction of expensive new homes on the north fillet and the periodic bulldozing of surplus sand bespeaks the best argument for the plaintiffs' case." Pls.' Mem. 13. However, even if Mr. Marzke's testimony is considered as support, almost none of what "bespeaks the best argument for the plaintiffs' case" was introduced into evidence or explained by expert or other testimony at trial.

Plaintiff-witnesses' testimony paints a vivid portrait of the difficulties plaintiffs have encountered in attempting to protect their property from the erosion that has already claimed much of it. This evidence serves to highlight the fact of erosion occurring south of the jetties, but it does not establish the cause of that erosion or that any amount of the erosion is attributable to defendant. See Def.'s Br. 6-10. There is testimony stating that increased erosion occurred during storms, see Tr. 785:10-12 (Miller); Tr. 303:23-309:22 (Chapman), as well as testimony to steady erosion at other times, see Tr. 894:1-895:10 (Marzke); Tr. 519:8-14 (Melcher), all of which is consistent with other evidence admitted in this case, see, e.g., PX 94 (1983 Report) 1, 8, 10; Tr. 112:8-11 (Meadows); Def. Br. 6-7. Nevertheless, without scientific analysis or any qualifications of these witnesses as experts, Fed. R. Evid. 701; see Part I n.11 supra, this lay testimony does little more than corroborate the scientific evidence that supports facts undisputed in this litigation: that the shoreline south of the harbor is eroding, Def.'s Br. 6 ("Plaintiffs established . . . that the jetties can cause erosion." (emphasis and capitals omitted)); Pls.' Br. 46-47, that there is background erosion due to natural processes, see, e.g., Tr. 112:8-11 (Meadows); Tr. 234:2-6 (Chrzastowski); PX 93 (1973 Report) 32, that the lake is at a low level at present, Tr. 89:2-11, 95:15-21 (Meadows); Tr. 491:23-25 (Thieme); Tr. 999:17-18 (Larson) (citing DX 30 (Lake-level history of glacial and post glacial lakes in the Lake Michigan basin)); Tr. 1346:20-23 (Konik), and that this low level appears to have slowed historical erosion processes for a time, see Tr. 94:5-7, 95:15-21 (Meadows); Tr. 235:9-236:20 (Chrzastowski); Tr. 1347:16-20 (Konik) (stating that more applications for permits to build shore protection are received when water levels are high); see generally Def.'s Br. 6-11.

2. Whirlpool Confined Disposal Facility

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recognizes, but it is no more than that. Without being authenticated as a learned treatise, the court will not elevate this evidence to the status of a learned treatise merely because it is received by the court on other grounds.

Plaintiffs also point out that, even during the years of mitigation, defendant placed some dredged material in a Whirlpool Confined Disposal Facility (CDF) "outside the littoral zone." Pls.' Br. 22; DX 34 (St. Joseph Dredging) 2; Tr. 633:22-634:15 (Selegean). Plaintiffs calculated the figure to be 407,739 cubic yards. Pls.' Br. 22-23.[76] Plaintiffs state that the Whirlpool CDF is "located about 3000 feet upstream on the PAW PAW River from its junction with the St. Joseph River," id. at 22 (citing PX 113 (1994 Site Visit Day 1) Fig. 8[77]), presumably to emphasize the undisputed fact that the Whirlpool CDF is located outside of the littoral zone, see Tr. 633:22-634:15 (Selegean) .

Dr. Selegean explained that contaminated material not suitable for beach nourishment is confined at the Whirlpool CDF, which acts as a landfill. Tr. 634:2-6 (Selegean). Plaintiffs argue that "[m]aterial washed downstream to the mouth of the flared entrance channel which is used as beach fill is not polluted." Pls.' Br. 23 (citing PX 93 (1973 Report) 52, Plate 2). This is presumably to counter Dr. Selegean's assertion that the contaminated material "generally represents material coming down the river or in the upper parts that are contaminated." Tr. 634:8-10 (Selegean). Page 52 of the 1973 Report states that "[a]ll materials lakeward of Section J, plate 2, are considered non-polluted." PX 93 (1973 Report) 52. This portion of the 1973 Report was not discussed or specifically pointed out at trial, see Tr. passim, and the court is uncertain whether this reference in fact supports the conclusion that river sediment is not polluted. Plaintiffs have failed effectively to counter Dr. Selegean's testimony regarding pollution in the St. Joseph River.

3. Nourishment for Southwest Regional Airport

Mr. Wesley explains that the Berrien Springs Dam on the St. Joseph River is not regulated by the FERC, which regulates most hydroelectric dams. Tr. 907:2-10 (Wesley); PX 90 (1999 River Assessment) 35; Pls.' Br. 28. Instead, "it has a permit issued by an Act of Congress in 1906. Damns not regulated under FERC operate without licenses and have limited regulation toward operation of the dam . . . ." PX 90 (1999 River

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[76]The court notes that the dredging quantities for years 1981 and 1982 include an unknown amount that was placed in "open water." DX 34 (St. Joseph Dredging) 2. This is of no consequence, however, because the significant fact is that the material was placed outside of the littoral zone. See id.

[77]The court notes that Figure 8 in PX 113 was not specifically pointed out at trial, see Tr. passim, but the court needs no expert testimony to interpret a basic map used to identify the location of the Whirlpool Confined Disposal Facility. Further, PX 113 is an admission.

Assessment) 35; Tr. 907:2-15 (Wesley); Pls.' Br. 28. Plaintiffs also assert that the Corps "exercises jurisdiction for navigation on the St. Joseph River up to Berrien Springs." Pls.' Br. 28. The court understands plaintiffs to be arguing that ultimate control of the activities on the St. Joseph River, and therefore ultimate responsibility for those activities, rests with defendant.

Plaintiffs focus on testimony by Mr. Wesley that he is aware of discussions to dredge material by or near St. Joseph Harbor and pump it to Southwest Regional Airport (Airport). Tr. 911:8-12 (Wesley); Pls.' Br. 28. He stated that he did not know whether those plans were being implemented, but also testified that his office would be involved if there were pumping going on. Tr. 911:13-21 (Wesley); Pls.' Br. 28. The court understands plaintiffs to be attempting to establish that sediment from the St. Joseph River – a possible source of sediment for the littoral zone at St. Joseph – may be diverted to the Airport, which could further deplete the littoral zone at St. Joseph. See Pls.' Br. 27-28; Pls.' Mem. 6 (arguing that even if the piers were corrected to prevent loss of river sand, "plaintiffs would never see the sand which would otherwise be theirs naturally" because of the pumping to the Airport).

The evidence indicates that the plan to pump material to the Airport has not yet been implemented, Tr. 911:8-21 (Wesley); Pls.' Br. 28, which plaintiffs acknowledge, Pls.' Mem. 6 ("[T]he Corps has a 30 year plan . . . . to pump the sand to a land fill, which would lengthen a runway for the hardly ever used Southwest Regional Airport.") (emphasis added). The court is not in a position to speculate about impacts of a program that has not been implemented.

4. Michigan Department of Transportation and Chesapeake and Ohio Railway Company Revetments

South of St. Joseph Harbor, the Chesapeake and Ohio Railway Company (C&O) and the Michigan Department of Transportation (MDOT) have constructed revetments protecting the railroad right-of-way and I-94 highway from erosion. PX 93 (1973 Report) 20. These revetments have been in place since long before the implementation of the mitigation program at St. Joseph Harbor. See id.

A revetment is a wall on the shore against which water crashes. Tr. 233:6-15 (Chrzastowski). Some energy from the waves will go downward and eat into the sediment at the foot of the wall and cause erosion of the lake bottom. Tr. 233:15-234:1 (Chrzastowski). The revetment protects a bluff from erosion by preventing sediment from dropping into the littoral zone, but that protection also depletes the sediment supply in the littoral system, exacerbating lake bottom erosion and steepening the nearshore

profile. DX 1 (Nairn Report) 4-140. As noted above in Part IV.B.1, steepening of the profile allows larger waves to reach closer to the shoreline and eat away at it, thereby increasing erosion rates downdrift of the revetments. See Tr. 106:18-107:1 (Meadows); Tr. 1224:3-17 (Nairn); DX 1 (Nairn Report) 4-140 to -141; Def.'s Br. 16.

Plaintiffs argue for the first time in Plaintiffs' Response that "the existence of the railway [C&O] and the highway (MDOT) revetments can be traced to the exhaustion of the sand supply due to the piers." Pls.' Resp. 6. In other words, plaintiffs argue that the C&O revetments and the MDOT revetments were constructed because of erosion due to depletion of the sand supply from the jetties, thereby implicitly attributing to defendant responsibility for increased erosion rates at plaintiffs' properties downdrift of the revetments. See id.

Dr. Meadows testified that the MDOT and C&O revetments would have had to be installed eventually absent the jetties, "but not for a substantial amount of time." Tr. 134:19-23 (Meadows). Dr. Chrzastowki agreed, stating that there "would . . . be a delay in the need to build revetments for the railroad if there had been no jetties built in the first place." Tr. 240:15-18 (Chrzastowki). He implied that he held the same opinion for the MDOT revetments. Tr. 226:20-25 (Chrzastowki) ("We have to remember, though, what caused the erosion and required the revetment at the MDOT and C&O revetment."). No dates were suggested by either Dr. Meadows or Dr. Chrzastowski in connection with their comments about the MDOT and C&O revetments. See Tr. passim.

Defendant argues that the C&O and MDOT revetments were not built to combat jetty-induced erosion. Def.'s Br. 18-19. Rather, defendant argues that the revetments were installed because the C&O and MDOT buildings were built too close to the shore. Id. Dr. Nairn's report and testimony addressed this issue: Dr. Nairn testified during trial that "[a]n accepted coastal engineering standard for a stable slope allowance adjacent to infrastructure at the top of a bluff is 2.5 times the height of the bluff," Def.'s Br. 18 (citing Tr. 1219-1248 (Nairn); DX 1 (Nairn Report) 4-138 to -141, 4-143; DX 2 (Supplemental Report on Review of Plaintiff[s'] Experts' Reports); DX 8 (Nearshore Slope Change History Offshore in Front of C&O Railway Revetment); DX 9 (Railroad Location); DX 22 (Bluff Erosion Rates); DX 129 (Michigan Department of State Highways General Plan of Project); DX 131 (Michigan Department of State Highways Sections); DX 140 (Proposed Embankment Protection South of St. Joseph, Mich.); PX 102 (1871 Map of East Shore of Lake Michigan)), and that the C&O railway line was built too close to a naturally eroding bluff, Def.'s Br. 19; Tr. 1232:25-1233:11 (Nairn). Defendant argues that both C&O and MDOT built their revetments in order to protect the railway and road, respectively, which had been built too close to the eroding bluff. Def.'s Br. 19. These revetments, defendant states, "not only resulted in steepening of the

nearshore profile in these areas, [they] also reduced the supply of sand to the south (by eliminating supply through natural erosion) and effectively set off a domino effect of shore protection further down the shore to the south." Id. Plaintiffs refer to no evidence to contradict Dr. Nairn's calculations. See Pls.' Br. passim; Pls.' Resp. passim.

Dr. Nairn testified that the C&O revetment, in principle, would have been necessary immediately after construction of the railroad to protect the bluff from erosion because the railroad construction was near the edge of a slope too steep to be stable. Tr. 1232:25-1233:11 (Nairn); Def.'s Br. 18. The MDOT revetment, however, differs from the C&O revetment because "that protection wasn't required immediately because they had 120 feet to spare." Tr. 1245:24-1246:1 (Nairn). Dr. Nairn testified that the MDOT protection would have been required by 1940 even without the harbor. Tr. 1247:12-16 (Nairn); see generally id. at 1247:19-1248:8 (Nairn).

Even in the absence of Dr. Nairn's uncontradicted calculations and testimony as to the need for construction of the revetments absent the harbor, plaintiffs fail to meet their burden of proof to show that defendant caused plaintiffs' injury indirectly though the MDOT and C&O revetments. Dr. Meadows and Dr. Chrzastowki, advocates of the proposition that the jetties at least partially sped up the need for the revetments, did not testify to or calculate how much the jetties sped up the need for constructing the MDOT and C&O revetments. See Tr. passim. Nor did they quantify the percentage of the reduction in sediment attributable to the MDOT and C&O revetments as distinguished from any reduction attributable to the jetties. Tr. 237:9-15 (Chrzastowki); Tr. 140:10-19 (Meadows). In addition, Dr. Chrzastowki admitted that the MDOT and C&O revetments "would have had to be placed, regardless of the jetties because of their location, on a naturally eroding shoreline" at some unspecified point in time. Tr. 234:11-15 (Chrzastowki). Indeed, the 1973 Report was written after the construction of these revetments and takes them into account: "[A]ll shore protective structures within the shore damage area would have been constructed regardless [of whether the harbor was built] because erosion attributable to the harbor is only about 30 percent of the total erosion due to all causes." PX 93 (1973 Report) 30. With no quantitative analysis to support plaintiffs' position, and with credible and unrefuted analysis to support defendant's position, the court cannot attribute responsibility for those revetments – and by extension any erosion they may have caused to plaintiffs' properties – to defendant.

5. Lowering of Water Level of Lake Michigan[78]

[78]The section of plaintiffs' briefing discussing this topic is titled "Lake Michigan is Receding." Pls.' Br. 25. To avoid confusion, the court uses "recession" to mean the horizontal shoreline recession at the edge of the lake rather than vertical water level lowering. The court

Plaintiffs present evidence that the water level of Lake Michigan is lowering. Dr. Larson testified that the current lake is about 10 to 15 feet lower than the lake that existed 5,000 years ago. Tr. 1052:19-25 (Larson); Pls.' Br. 25. The 1973 Report is consistent with Dr. Larson's testimony, stating that the lake bed of Lake Michigan has been lowering. PX 93 (1973 Report) 8 ("Subsequent stages of rising and falling lake levels reduced the Lake Michigan Basin to present levels and outline.");[79] Pls.' Br. 25. Plaintiffs conclude with the following argument:

> The lowering of Lake Michigan contradicts the theory of a naturally eroding shore. . . . The plaintiffs cannot rest assured that based on lake level lowering they can escape erosion because the dominant factor is lakebed lowering caused by sand

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refers to "recession" of the bottom of the lake as lake bottom or lake bed lowering or (with respect to cohesive shores) down-cutting.

[79]This section of PX 93 was not specifically point out or discussed at trial. See Tr. passim.

Plaintiffs cite to PX 130 as support that there is a long-term trend toward lower water levels at Lake Michigan. Pls.' Br. 25-26. The court cannot rely on PX 130 as authoritative evidence in support of the lowering of Lake Michigan. Its technical nature requires that it be qualified as a learned treatise by the testimony of the expert who relied upon it or to whose attention it was called. Fed. R. Evid. 803(18) (exceptions to the hearsay rule). When statements from a learned treatise are admitted into evidence, they may be read to the finder of fact, "but the statements themselves may not be admitted as documentary evidence unless they are admissible under some other exception to, or exclusion from, the hearsay rule." Matthew Bender 1-6 Fed. Evid. Practice Guide § 6.06(18). "Statements contained in a 'learned treatise' are admissible under [FRE 803(18)] to the extent they have been relied upon by an expert witness in the formulation of his or her direct testimony or if they have been called to his or her attention during cross-examination." Id.

Plaintiffs' Exhibit 130 was discussed with Dr. Selegean, but Dr. Selegean never authenticated PX 130 or recognized it as a learned treatise. See Tr. 611:17-23 (Selegean). Dr. Selgean testified that "[t]his document has made it into the newspapers in the Detroit area, so I know generally what I've read in the newspapers. It's also been discussed around the office. . . . But I haven't read this document." Id. The court erred in admitting PX 130 as an exhibit and will not compound that error by relying on it now.

Plaintiffs also cite to page 25 of the 1958 Study as support of their argument that Lake Michigan is lowering, but the page concerns potential mitigation rather than a history of lake-level lowering. See PX 132 (Berrien County, Michigan, Beach Erosion Control Study (1958 Study)) 25.

deprivation. This lets the lake advance shoreward even though the lake level is going down.

Pls.' Br. 26.[80]

Although plaintiffs present persuasive evidence that the water level in Lake Michigan is lowering, Tr. 1052:19-25 (Larson); PX 93 (1973 Report) 8; Pls.' Br. 25-26, they present no persuasive evidence that this lowering in the St. Joseph area is due to human intervention from the St. Joseph Harbor. While plaintiffs make a point of citing sources that indicate that Lake Michigan has been lowering for thousands of years, they do not distinguish different periods within those thousands of years that could indicate that the St. Joseph Harbor has affected that lowering. See Tr. 1052:19-25 (Larson); see also PX 93 (1973 Report) 8; see also Pls.' Br. 25-26. In fact, the evidence that plaintiffs cite presents many other reasons as causes of lake water lowering. See e.g., PX 93 (1973 Report) 8 ("Following the 18-foot level, the ice border retreated farther north uncovering the Straits of Mackinac . . . exposing a lower outlet to the east. This outlet reduced the level of the Lake Michigan Basin to about 10 feet above the present level."). Further, plaintiffs present no evidence and no explanation of how "[t]he lowering of Lake Michigan contradicts the theory of a naturally eroding shore," Pls.' Br. 26, especially in light of the fact that all of the evidence presented at trial from both parties indicated that natural erosion occurs around St. Joseph Harbor. Tr. 95:15-17 (Meadows); Tr. 1195:19-21 (Nairn).

V. Conclusion

A. Plaintiffs with a Sandy Shore

Most of plaintiffs' properties are located in a zone that Dr. Larson's and Dr. Nairn's studies identify as fronting on a sandy lake bed. See Part IV.B.1. This section discusses the liability of the Corps as to those plaintiffs.

1. Erosion Damage that Occurred Prior to 1970

Plaintiffs refer to defendant's "dredging records," presumably DX 34, to argue that

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[80]Plaintiffs also refer to an argumentative colloquy between Dr. Larson and plaintiffs' counsel in which Dr. Larson acknowledged the vertical accretion of dunes due to sand blowing "up off the beach" during the 5,000-year period that the lake dropped 10 to 15 feet. Tr. 1052:9-1055:12 (Larson); Pls.' Br. 25-26. So far as the court can discern, this colloquy explains nothing about subsurface conditions that would affect the water level of Lake Michigan.

defendant did not consider 73 years that, when considered, "add[] 6,234,273 [cubic yards] more removed from the littoral zone." Pls.' Br. 22; DX 34 (St. Joseph Dredging);[81] see Tr. 622:15- 636:25 (Selegean) (testifying how he compiled this record, how the chart is organized, and what the figures mean). The court infers that plaintiffs are pointing out that, regardless of defendant's recent attempts at mitigation, defendant made no effort to mitigate any erosion prior to 1972, when the Corps started sidecasting sediment over the south pier and into the littoral zone. See DX 34 (St. Joseph Dredging); Tr. 633:8-18 (Selegean) (explaining that to "sidecast" over the south pier means that the Corps "extended a pipe over the jetty to the south side and then pumped the material that was inside the dredge . . . out to the south side. So they pumped it over the jetty wall to roughly the area where the southern beach would be, not on the beach but out in the water"). This is the only inference the court was able to draw from plaintiffs' arguments and DX 34, which plaintiffs cite in support. See Pls.' Br. 22-23; DX 34 (St. Joseph Dredging). The figure of 6,234,273 cubic yards includes erosion prior to 1950, notwithstanding the court's earlier opinion ruling, consistent with plaintiffs' then position, that liability would not include erosion that occurred prior to 1950. Banks (scope) I), 68 Fed. Cl. at 535. Plaintiffs may not change their litigation position in post-trial briefing, nor may they relitigate an issue that has already been decided.

Defendant states that Dr. Nairn employed the sediment budget "to determine whether the Corps had provided enough sediment to the shoreline to offset any erosion attributable to the jetties." Def.'s Br. 12 (citing Tr. 1117:14-21 (Nairn)). Defendant points out that Dr. Nairn concluded that any net erosion is not due to the jetties because "the volume of sediment provided by the Corps to the shoreline south of the St. Joseph Harbor since 1970 is sufficient to have offset any erosion attributable to the jetties." Def.'s Br. 13. Dr. Nairn testified that "[s]ince 1970, [the Corps] has on average placed more sand south of the harbor than has been trapped or lost through the influence of the jetties and the dredging program of the harbor." Tr. 1117:3-6 (Nairn).

It is undisputed that defendant failed to mitigate for any erosion prior to the early 1970s. See DX 34 (St. Joseph Dredging); Tr. 622:15- 636:25 (Selegean); Tr. 1117:3-6 (Nairn); Def.'s Br. 12. However, defendant and plaintiffs are in disagreement over when mitigation actually began. Plaintiffs implicitly argue that mitigation began in 1972, when defendant started sidecasting sediment over the south jetty and into the littoral zone. See

[81]In the course of compiling its exhibits, defendant erroneously placed the wrong document in the binders where DX 34 was to have been placed. Tr. 562:3-4. Defendant's counsel stated that "Plaintiffs have had [the correct DX 34] since Dr. Selegean was deposed back in 2005." Tr. 562:2-562:3. Without objection by plaintiffs, the court allowed defendant to substitute the correct exhibit at trial. Tr. 561:4-562:8.

Pls.' Br. 22; DX 34 (St. Joseph Dredging); Tr. 633:8-18 (Selegean).

Defendant's position is that mitigation began in 1970, when the Corps placed the dredged material "two miles south of the piers in 10-20 ft. of water." DX 34 (St. Joseph Dredging) (capitals omitted); Tr. 632:11-19 (Selegean). Defendant's testimony and DX 34 are consistent with activities undertaken to comply with the Marine Protection, Research, and Sanctuaries Act of 1972 (Ocean Dumping Act), Pub. L. No. 92-532, which "put much more stringent regulations on dumping offshore. And that's why the offshore dumping actually ceased and the sand came to the nearshore zone instead." Tr. 1162:9-14 (Nairn). The record also shows the 1970 and 1971 placements, noting the offshore location in the column for the littoral zone. DX 34 (St. Joseph Dredging); Tr. 632:6-10 (Selegean); Tr. 348:10-11 (Selegean) ("[The nourishment program is] still going on and we've beach nourished every year since 1970."); Tr. 607:19-20 (Selegean) ("The Corps started beach nourishing in St. Joseph in 1970.");[82] see DX 1 (Nairn Report) 1-14 ("Since 1970, the [Corps] has on average placed more sand south of the harbor than has been trapped or lost through the influence of the jetties and the dredging program at the harbor."); Tr. 1117:3-6 (Nairn).

The nourishment program at St. Joseph under Section 111 of the Rivers and Harbors Act of 1968, Pub. L. No. 90-483, § 111, 82 Stat. 731, 735 (1970), was not implemented until 1976. PX 23 (1996 Report) 2 ("In 1976, an approved Section 111 erosion mitigation plan authorized annual placement of fill material . . . from maintenance dredging of St. Joseph Harbor to feed the eroding downdrift shoreline."); PX 24 (1997 Report) 5 ("A Section 111 mitigation plan was implemented downdrift of St. Joseph Harbor in 1976 by the [Corps] to address the erosion problems that may be associated with the interception of sediment on the updrift side of the structures."). However, the Corps' effect on erosion is at issue and not the purpose of measures that could effect mitigation; mitigation incidental to another activity carries no less weight than purposeful mitigation. Defendant's Exhibit 34 clearly indicates that nourishment was placed in the littoral zone beginning in 1970. DX 34 (St. Joseph Dredging) 1. Plaintiffs' counsel never attempted to impeach or question this evidence, see Tr. passim. As the 1997 Report notes: The nourishment program "was initiated in 1976 (with some nourishment placed as early as 1970)." PX 24 (1997 Report) 83. The court finds that mitigation at St. Joseph Harbor began in 1970.

The court disagrees with plaintiffs' view of possible damages. Plaintiffs offered

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[82]In response to the court's inquiry as to whether there is a difference between mitigation and beach nourishment, Dr. Selegean testified that "our form of mitigation right now is beach nourishing." Tr. 608:2-7 (Selegean).

counsel's calculations of the loss of sediment for a period covering ninety-four years. Pls.' Br. 22. Plaintiffs quote from United States v. Dickinson, 331 U.S. 745, 750 (1947) ("[P]ayment need only be made for what is taken, but for all that the Government takes it must pay.") to argue that "all of the material removed from the littoral system must be compensated for." Pls.' Br. 33 (quotation corrected to conform to reported decision). Leaving aside problematic aspects of the calculations, including arithmetic[83] and the time period involved,[84] defendant is not liable for the amount of sediment removed from the littoral zone; rather, defendant is liable for unmitigated erosion above the high water mark that it caused to plaintiffs' properties. Plaintiffs misread Dickinson. The government must pay for all that it takes from plaintiffs above the high water mark and during the time of any particular plaintiff's ownership and, in this case, not before 1950, Banks (scope) I), 68 Fed. Cl. at 535; defendant is not required to compensate plaintiffs for

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[83]Plaintiffs calculated that the "[t]otal (by attorney Ehret) for 94 years was 8,027,781 cy/yr." Pls.' Br. 22. Defendant's Exhibit 34 has entries for years 1900 to 2004, that is, 105 years of dredging records. DX 34 (St. Joseph Dredging). For nine of these years, the quantity dredged and placed back into the lake are "unknown." Id. For two of those years, the quantity is 0. Id. The court presumes that the plaintiffs' attorney averaged the 94 years that were known and that had some quantity dredged and placed into the lake above 0.

An initial problem with plaintiffs' counsel's calculations is that a total indicates the total cubic yards dredged rather than the cubic yards per year; the court assumes this was an unintended error in the units recorded. A second problem is that plaintiffs are unclear whether the 8,027,781 cubic yards total represents the sum of the sediment dredged or the difference between the total dredged and the total placed back into the littoral zone. A third problem is that a correct average should include all known quantities, even those quantities that are zero. See American Heritage Dictionary at 124 (4th ed. 2000) (defining "average" as "[a] number that typifies a set of numbers of which it is a function"); id. at 97 (defining "arithmetic mean" as "[t]he value obtained by dividing the sum of a set of quantities by the number of the quantities in the set. Also called average."). Finally, while it would be fair to ascribe an average, representative quantity to the years where there is no record of the dredging and placement quantities, there is no reason to supersede actual records with averages. If the court were to calculate the amount dredged during the years where there was no mitigation, it would not multiply the total number of years not considered by defendant with the average cubic yards per year, as plaintiffs did, Pls.' Br. 22; rather, it would multiply the number of years with unknown records by the average cubic yards per year and add that sum to the sum of the actual quantities known to have been dredged prior to mitigation. The same methodology would apply for calculating the quantities of material placed in the littoral zone.

[84]Plaintiffs' calculations include years prior to 1950 even though the court held that it would consider damages from the beginning of the encasement of the jetties but no earlier than 1950. Banks (scope) I, 68 Fed. Cl. at 535.

impacts of all of the activities that may have eventually led to the taking. See Dickinson 331 U.S. at 750.

Prior to this litigation, defendant admitted in the Corps Reports liability for and a failure to mitigate the 30% of the total erosion south of the jetties. PX 93 (1973 Report) 32; PX 22 (1974 Report) 235; PX 41 (1999 Report) 4; Tr. 63:5-12 (Meadows) (testifying that, according to the 1973 Report, 30% of the total loss of sediment was 110,000 cubic yards per year) (citing PX 93 (1973 Report) 59); Tr. 655:16-21 (Selegean) ("[Thirty] percent of that total erosion the author claims [316,000 cubic yards per year] is due to the harbor.") (citing PX 93 (1973 Report) 32). At trial, defendant did not dispute this admission for the period prior to 1970. See Tr. passim; Def.'s Br. passim; Def.'s Resp. passim. Defendant's expert witness, Dr. Nairn, explicitly stated that he did not believe that the Corps has mitigated for the lost sand dumped into deep water from dredging prior to 1970. Tr. 1336:7-10 (Nairn). Accordingly, the court holds that defendant did not mitigate any of the erosion it admits to having caused prior to the 1970s and is responsible for it. Defendant is therefore responsible for damages for 30% of each plaintiff's total erosion above the high water mark that occurred after each plaintiff's acquisition of the property (but in no case earlier than 1950) to 1970. See also Banks (scope) I, 68 Fed. Cl. at 535 (holding that the court will determine defendant's liability from the time of property acquisition but no earlier than 1950); Part I n.7.

2. Erosion Damage that Occurred After 1970

Defendant argues that the Corps is not liable for any erosion after 1970, based on Dr. Nairn's conclusion that "[s]ince 1970, [the Corps] has on average placed more sand south of the harbor than has been trapped or lost through the influence of the jetties and the dredging program of the harbor." Tr. 1117:3-6 (Nairn); Def.'s Br. 13.

The Corps has mitigated some of the erosion it has caused since 1970. Part V.A.1 supra. The court found that coarse material, usually trucked in from outside of the littoral system, is not effective mitigation. Part IV.B.2 supra. Defendant is therefore responsible for damages for any portion of 30% of each plaintiff's total erosion above the high water mark since 1970, but not prior to acquisition, Banks (scope) I, 68 Fed. Cl. at 535 (holding that the court will determine plaintiffs' liability after property acquisition), that was not effectively mitigated by the Corps' nourishment. The Corps is also liable for damages for 30% of all reasonably foreseeable future loss. Part I n.6 supra.

B. Plaintiffs with Property at the Northernmost End of Plaintiffs' Zone

As discussed in Part IV.B.1 above, some property at the northernmost end of

plaintiffs' zone appears to be located in a cohesive lakeshore area. Part IV.B.1 holds that "erosion of cohesive material is permanent and irreversible." Therefore, the Corps' mitigation in this zone was ineffective, and defendant is liable for damages for 30% of total erosion above the ordinary high water mark that occurred after any such plaintiff's acquisition of the property (but in no case earlier than 1950) and for all reasonably foreseeable future loss. See also Banks (scope) I, 68 Fed. Cl. at 535 (holding that the court will determine plaintiffs' liability from the point of property acquisition but no earlier than 1950); Part I n.7.[85]

IT IS SO ORDERED.

s/ Emily C. Hewitt
EMILY C. HEWITT
Judge

[85]The court was introduced to a rate of recession of plaintiffs' shoreline in the MDEQ letter advising some plaintiffs of new setback requirements for their homes. PX Summary Tab 8; Tr. 245:20-246:11 (Wineberg). Several witnesses, however, testified that the recession rate identified in the letter was high. Tr. 255:11-14, 268:4-22 (Wineberg); Tr. 941:7-12 (Jannereth) (testifying that "15 feet [were] added to all recession rate distances to take into consideration the recession rate variability and the potential for a loss during a sudden storm"); Tr. 1187:22-1188:2 (Nairn). Dr. Chrzastowski relied on the rates from the MDEQ for his analysis, Tr. 208:9-11 (Chrzastowski) (citing PX 24 (1997 Report)), although he acknowledged in a deposition that it would be "prudent to take a conservative approach that gave landowners a sense of the greater rather than the lesser risk of erosion," Tr. 211:7-15 (Chrzastowski).

Dr. Nairn testified that the rate of recession of the shoreline, as calculated by the MDEQ, is "conservative" – that is, high, – because "they want to instruct property owners whether they should be aware that they're in a hazard or not" and "[t]hey don't want to underestimate that." Tr. 1187:22-1188:2 (Nairn). He testifies that "most of the[] recession rates [of the MDEQ] are roughly equivalent to the mean plus the standard deviation rate." Tr. 1189:7-8 (Nairn) (citing DX 27 (Comparison of Average Annual Bluff Recession Rates MDEQ to Nairn Expert Report, Lincoln Township (Recession Rates Comparison)); DX 2 (Supplemental Report on Review of Plaintiff[s'] Experts' Reports) 22.

Appendix

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